UNIVERSITY OF WASHINGTON

Implications of 21st Century Climate Change for the West Coast Water Resources: Results of the Accelerated Climate Prediction Initiative

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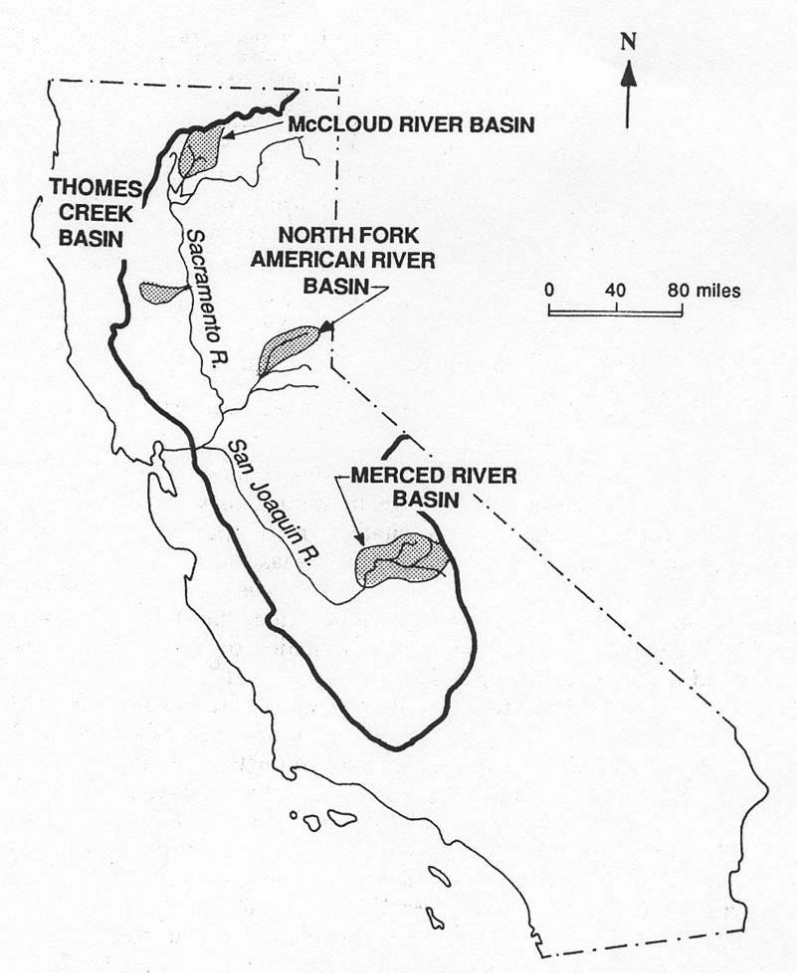
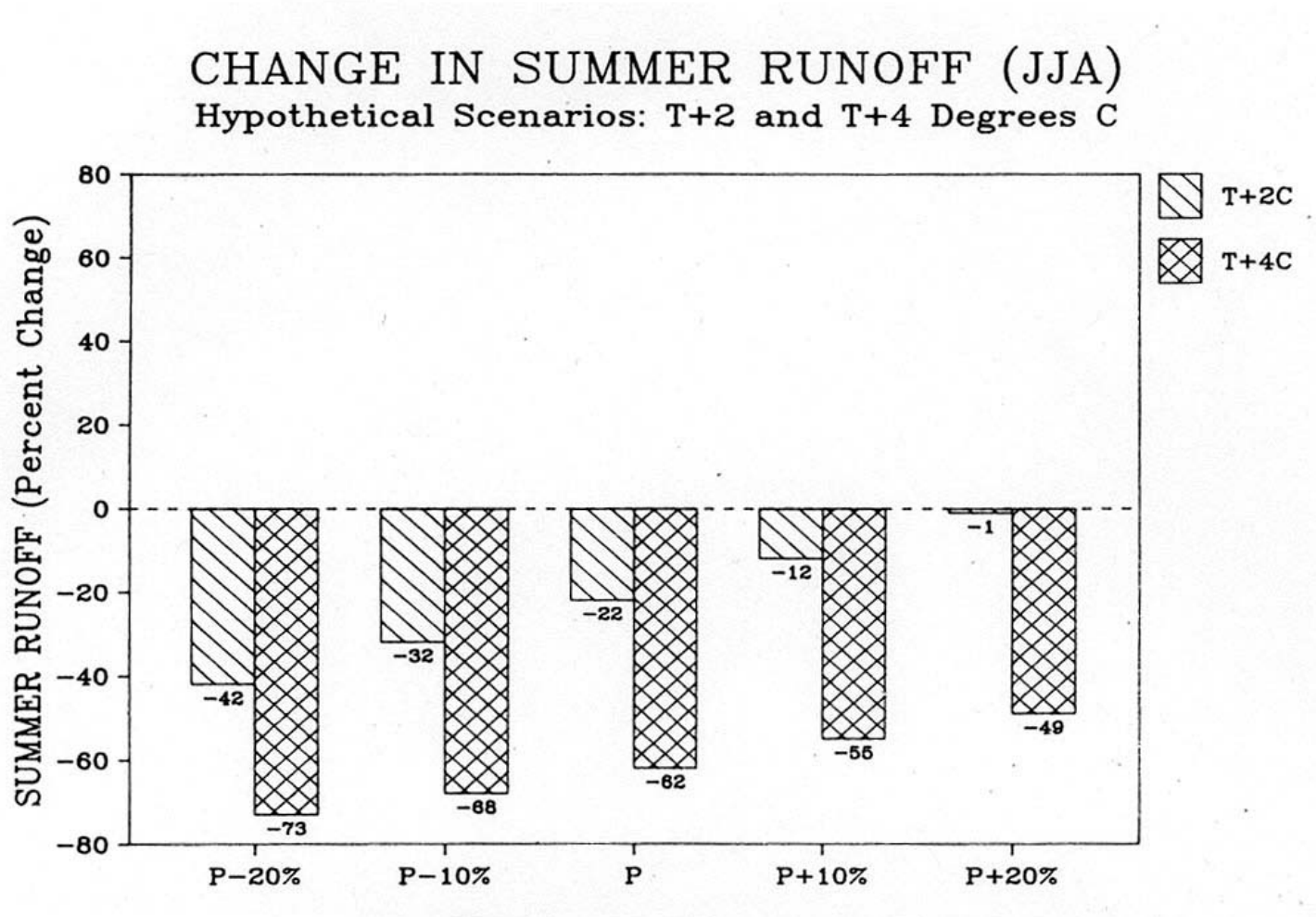
Outline of this talk

- History of water and climate change studies in CA
- ACPI – results for CA, PNW, CO
- Implications and outstanding issues

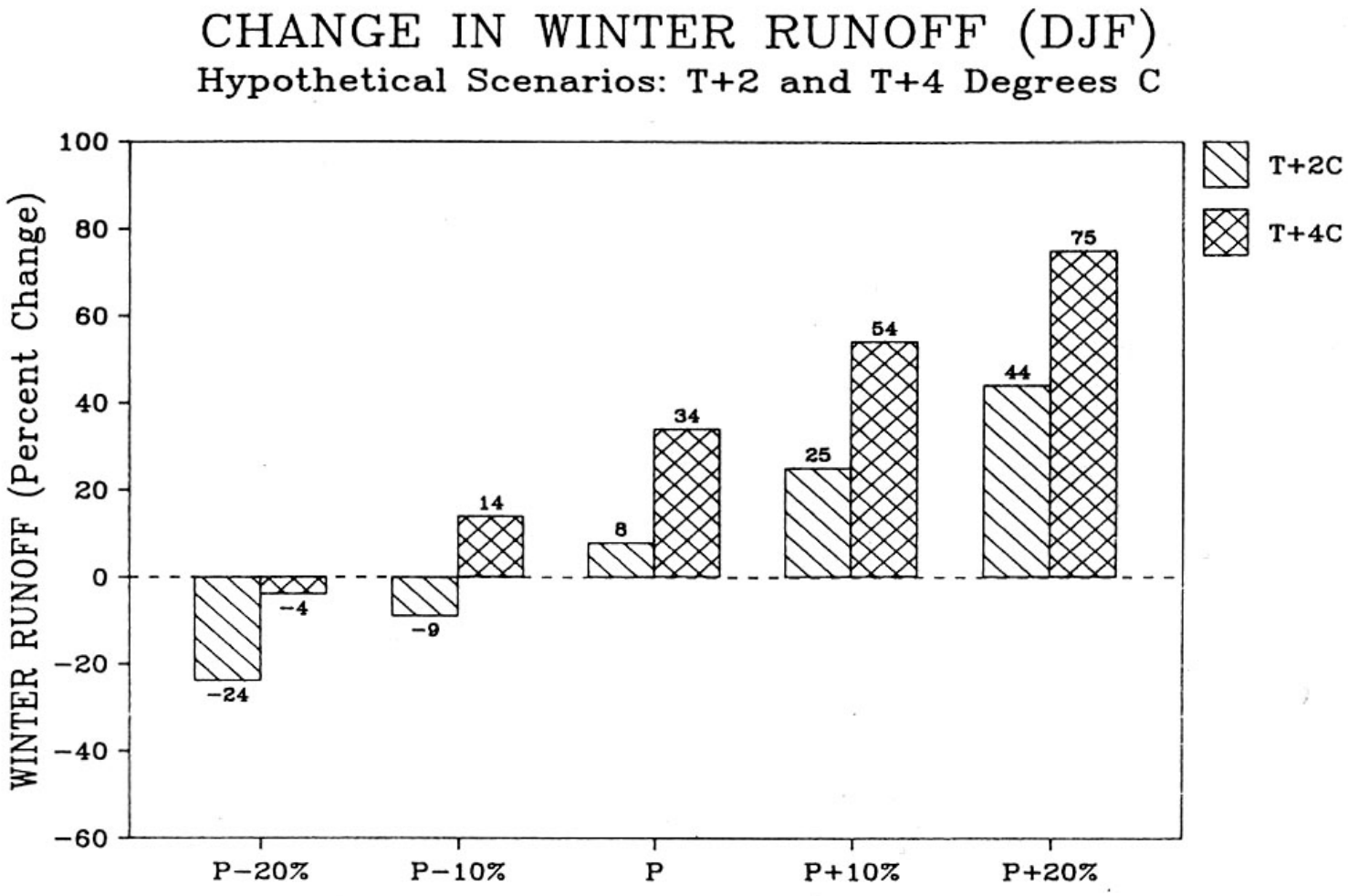
1) Early CA climate change studies



from Lettenmaier and Gan, WRR, 1990



from Gleick, WRR, 1987



from Gleick, WRR, 1987

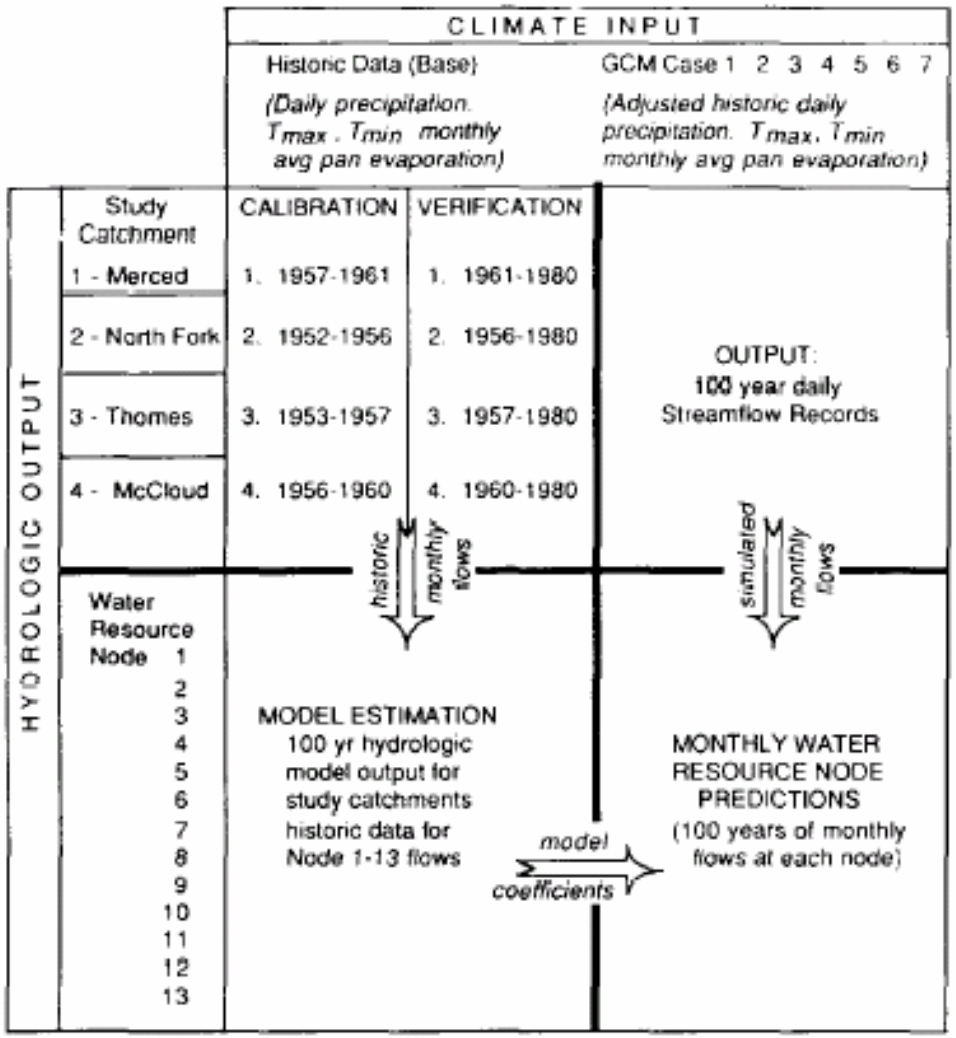


Fig. 1. Schematic overview of study design.

from Lettenmaier and Gan, WRR, 1990

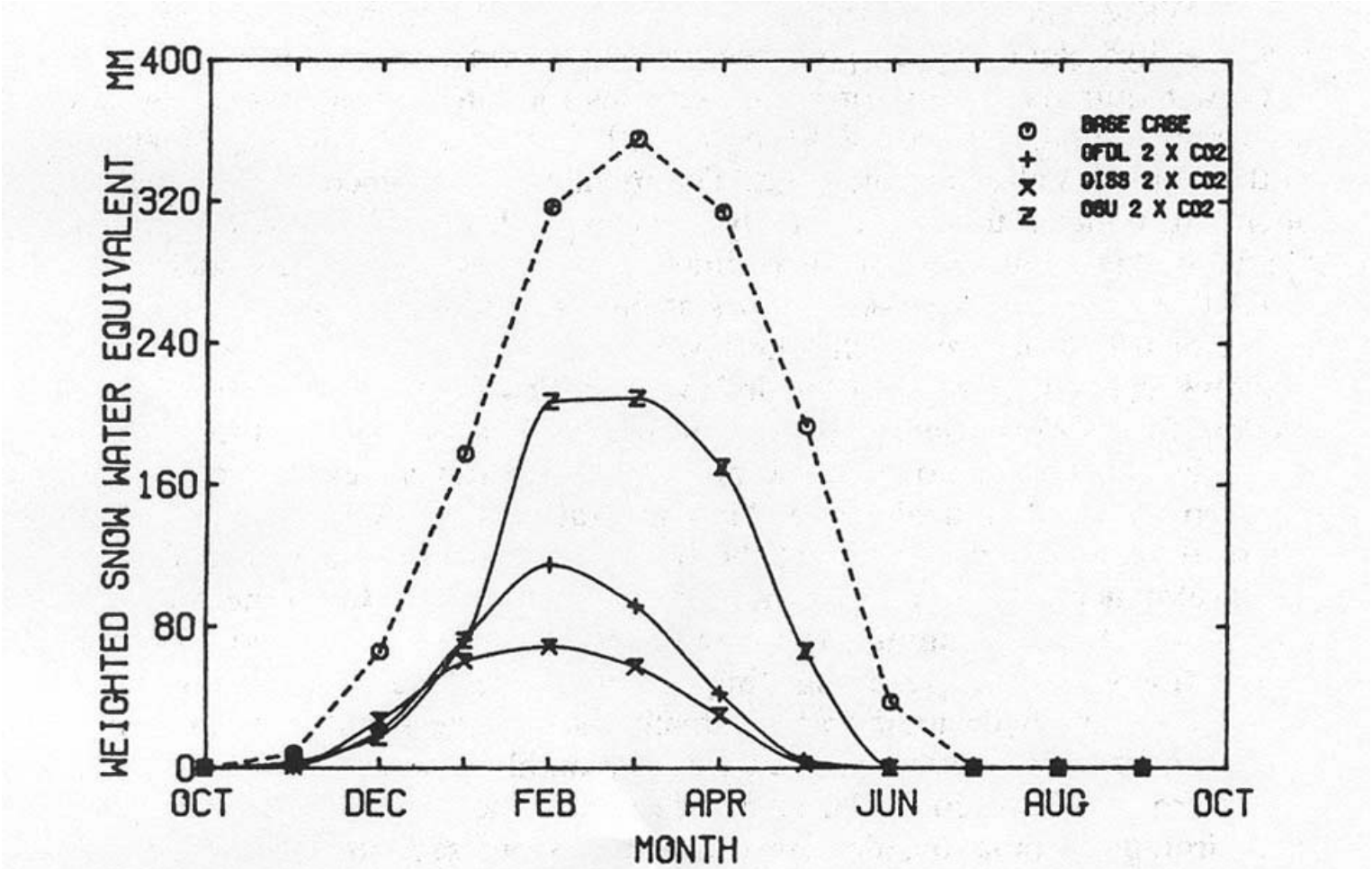


FIG. 3. Thomes Creek Simulated Basin-Average (Weighted Average of All Elevation Bands) 100-Year Mean Monthly Snow Water Equivalent under Present Conditions (Base) and Alternative Climates

from Lettenmaier and Sheer, JWRPM, 1991

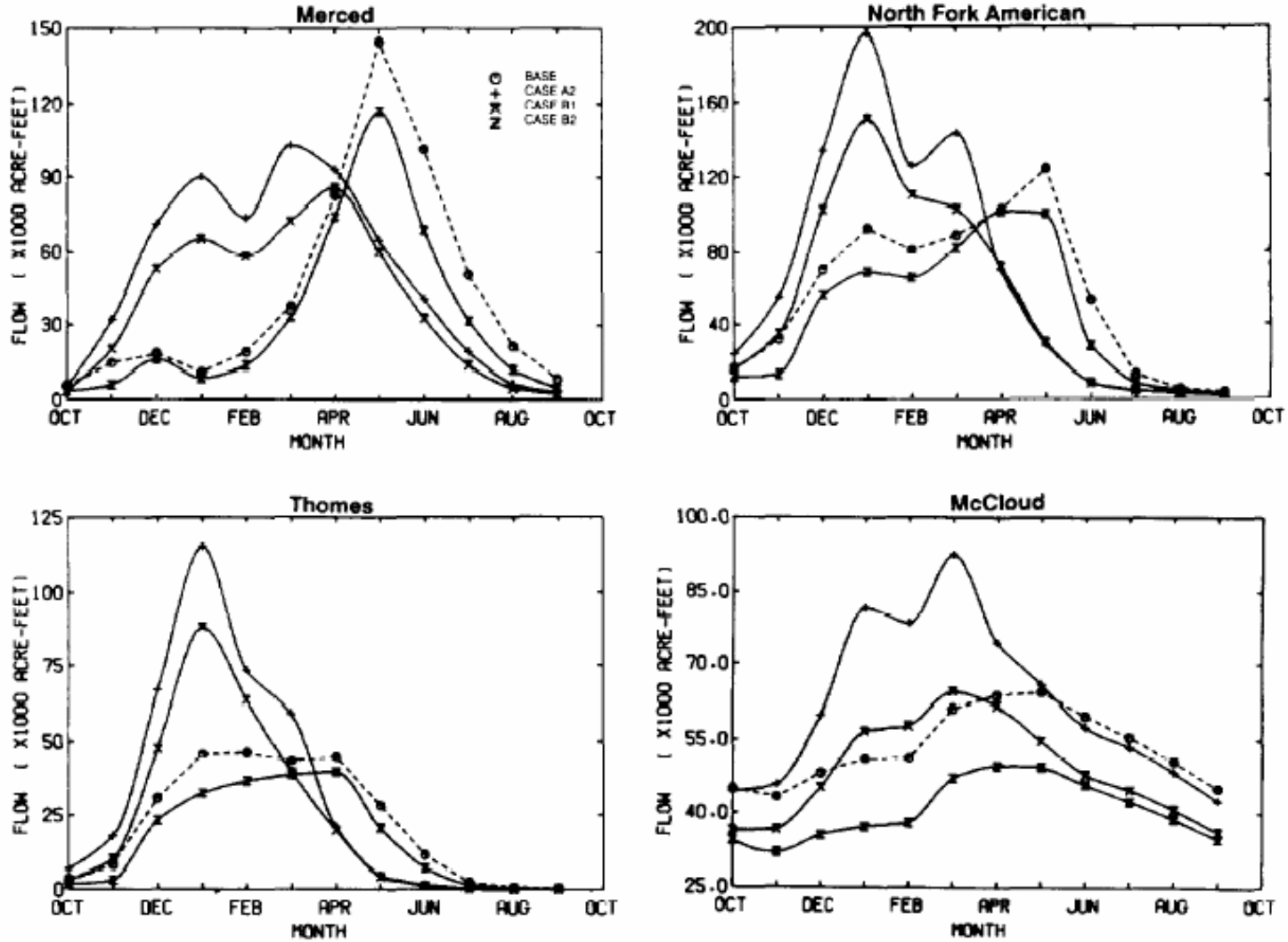


Fig. 10. Study catchment monthly mean streamflow for base case and climate sensitivity scenarios B1 and B2.

from Lettenmaier and Gan, WRR, 1990

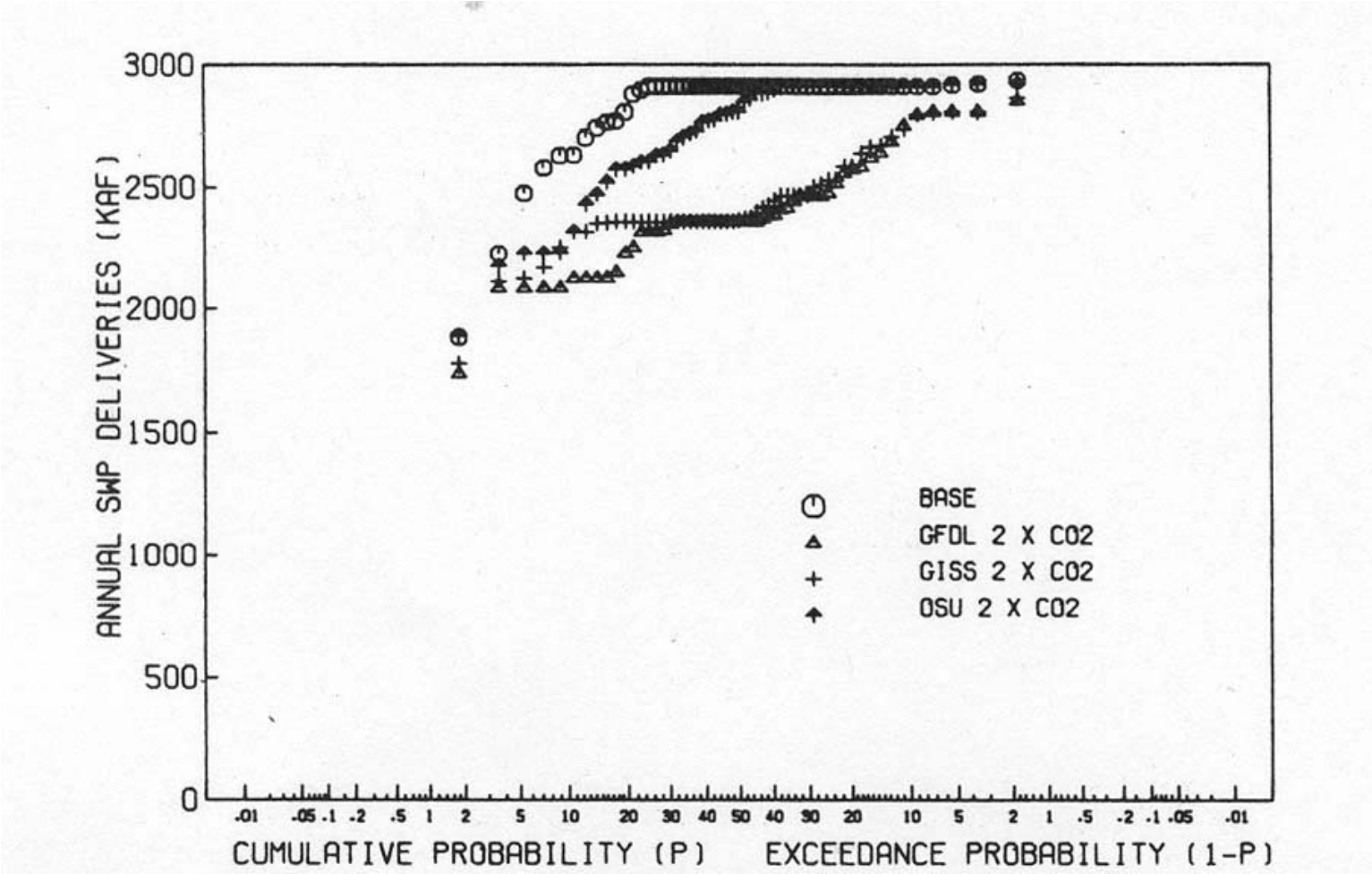


FIG. 5. Simulated Probability Distribution of Annual SWP Water Deliveries under Present Conditions (Base) and Alternative Climates

from Lettenmaier and Sheer, JWRPM, 1991

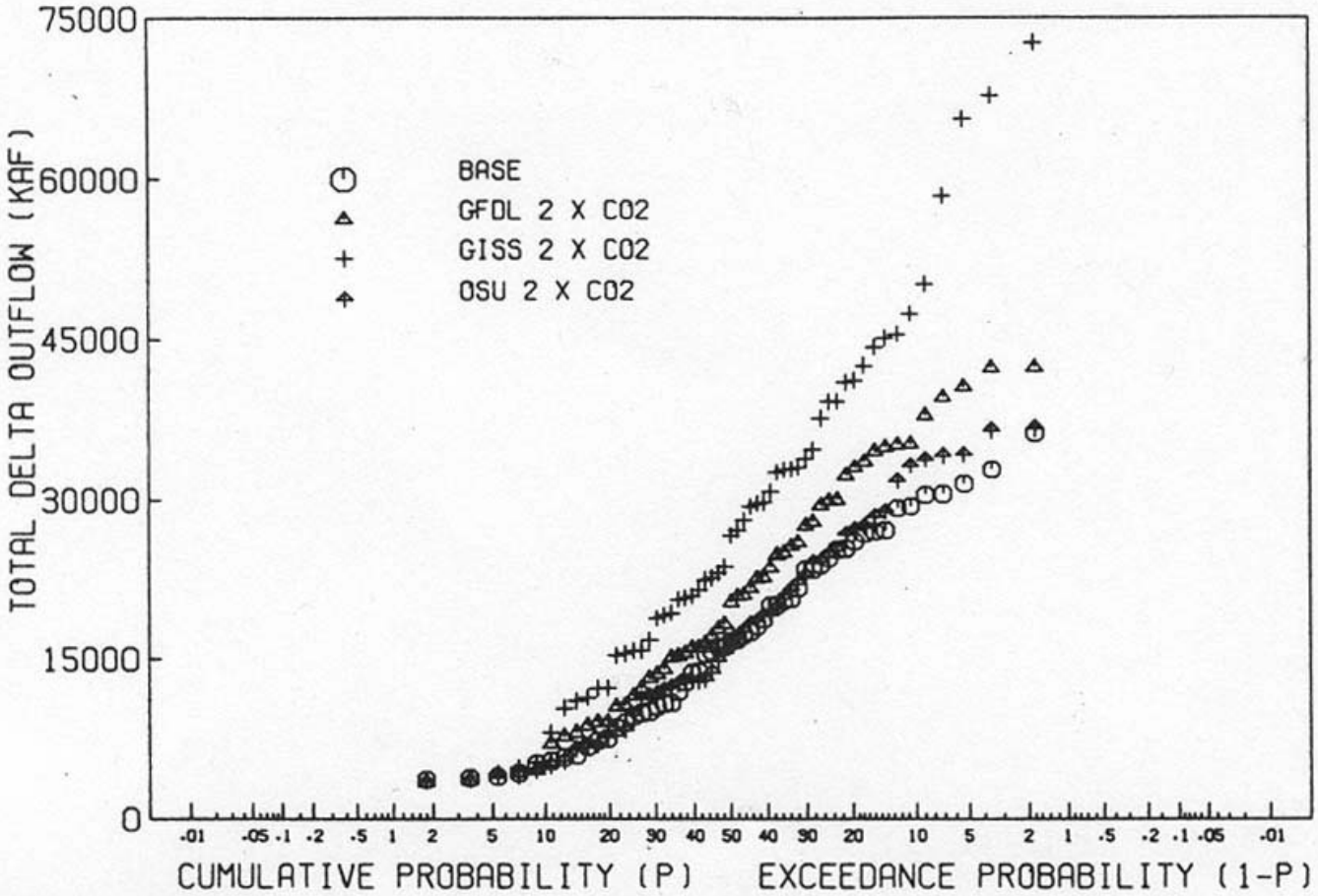


FIG. 7. Simulated Empirical Probability Distribution of Total Annual Delta Outflow under Historical Conditions (Base) and Alternative Climates Corresponding to Three GCM CO_2 Doubling Scenarios

from Lettenmaier and Sheer, JWRPM, 1991

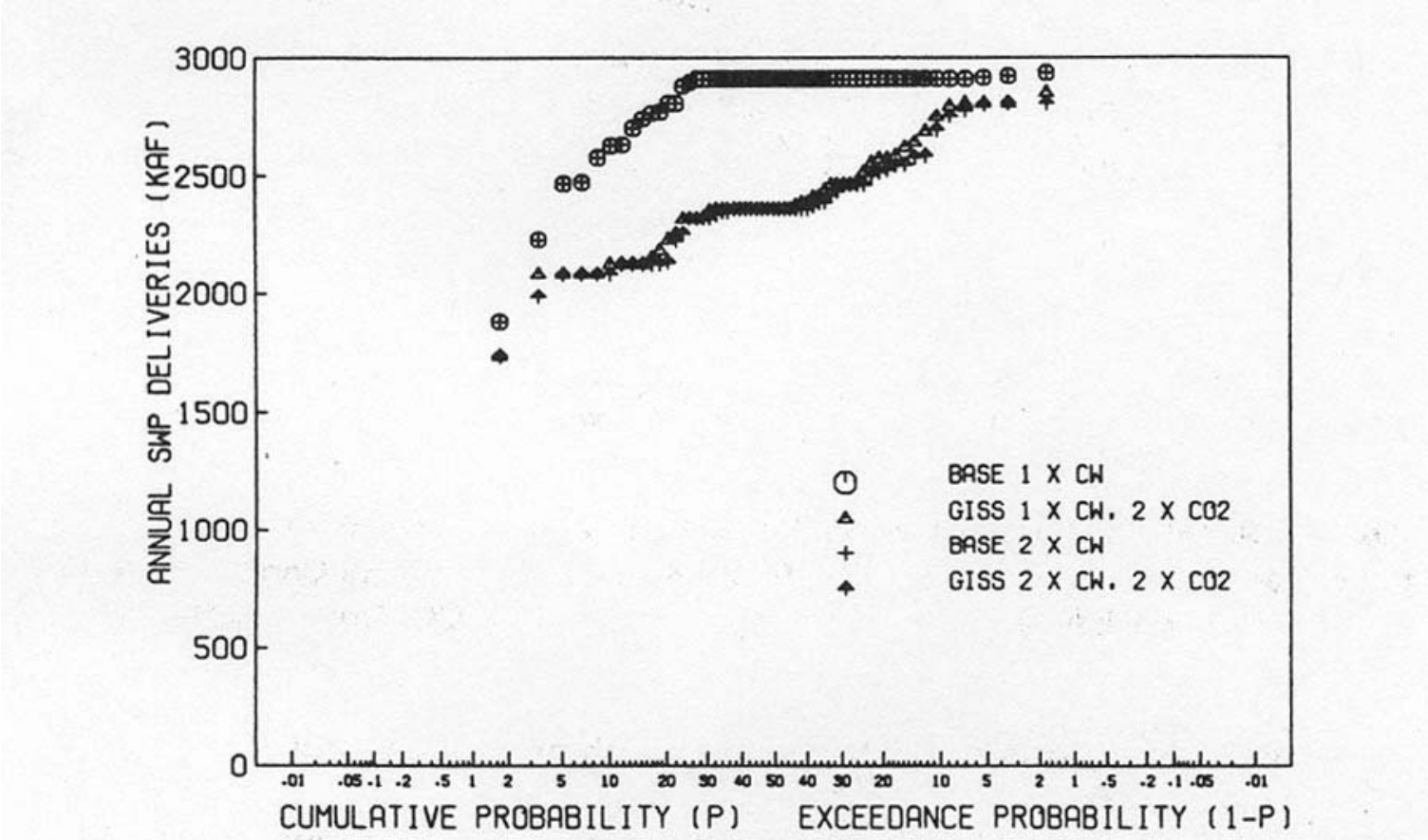
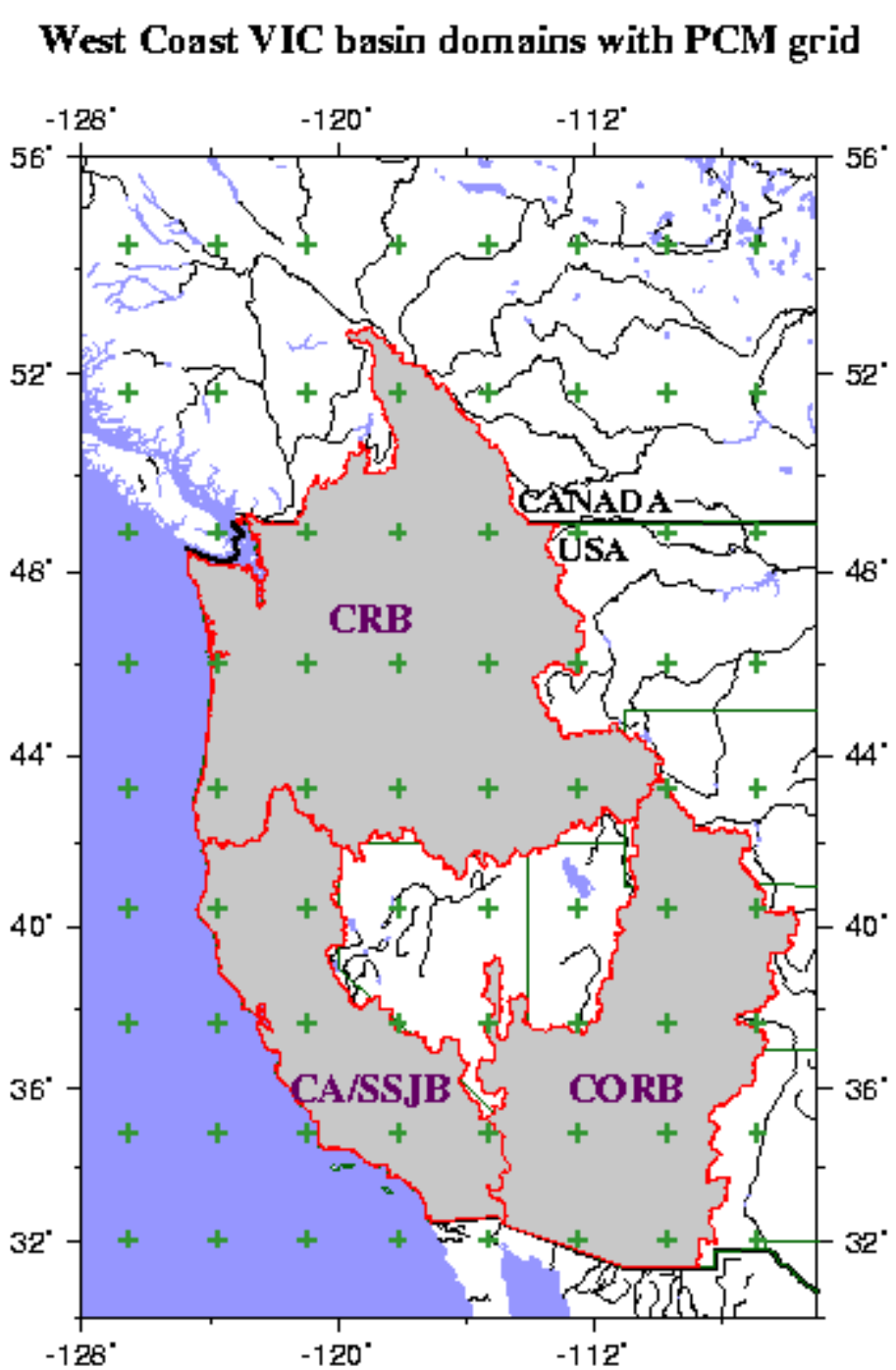


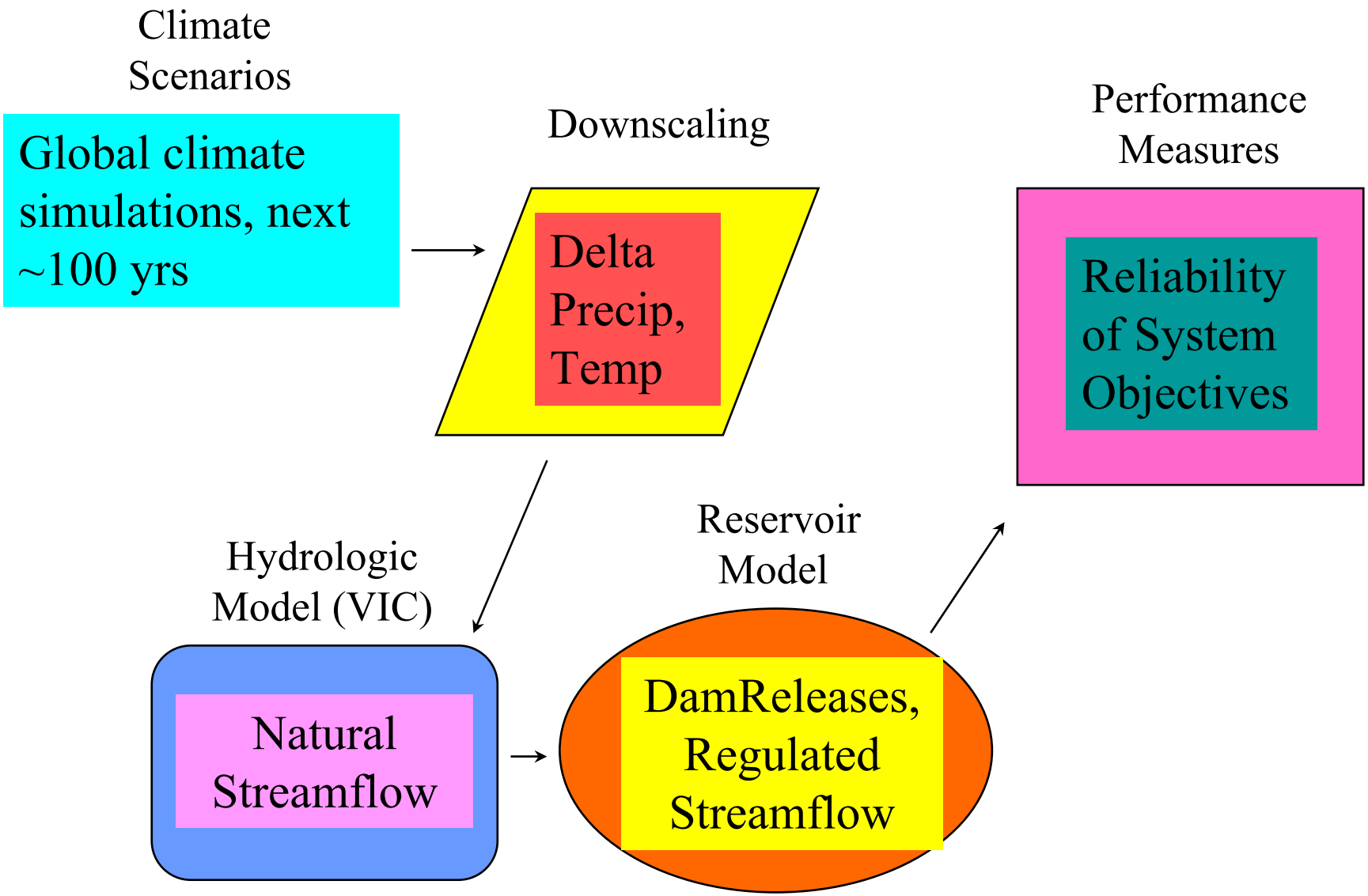
FIG. 8. Simulated Probability Distribution of Total Annual SWP Water Deliveries for Historical Conditions (Base) and for GISS Model CO_2 Doubling Scenario, for Current Carriage Water (CW) Requirement and Doubled CW Requirement

from Lettenmaier and Sheer, JWRPM, 1991

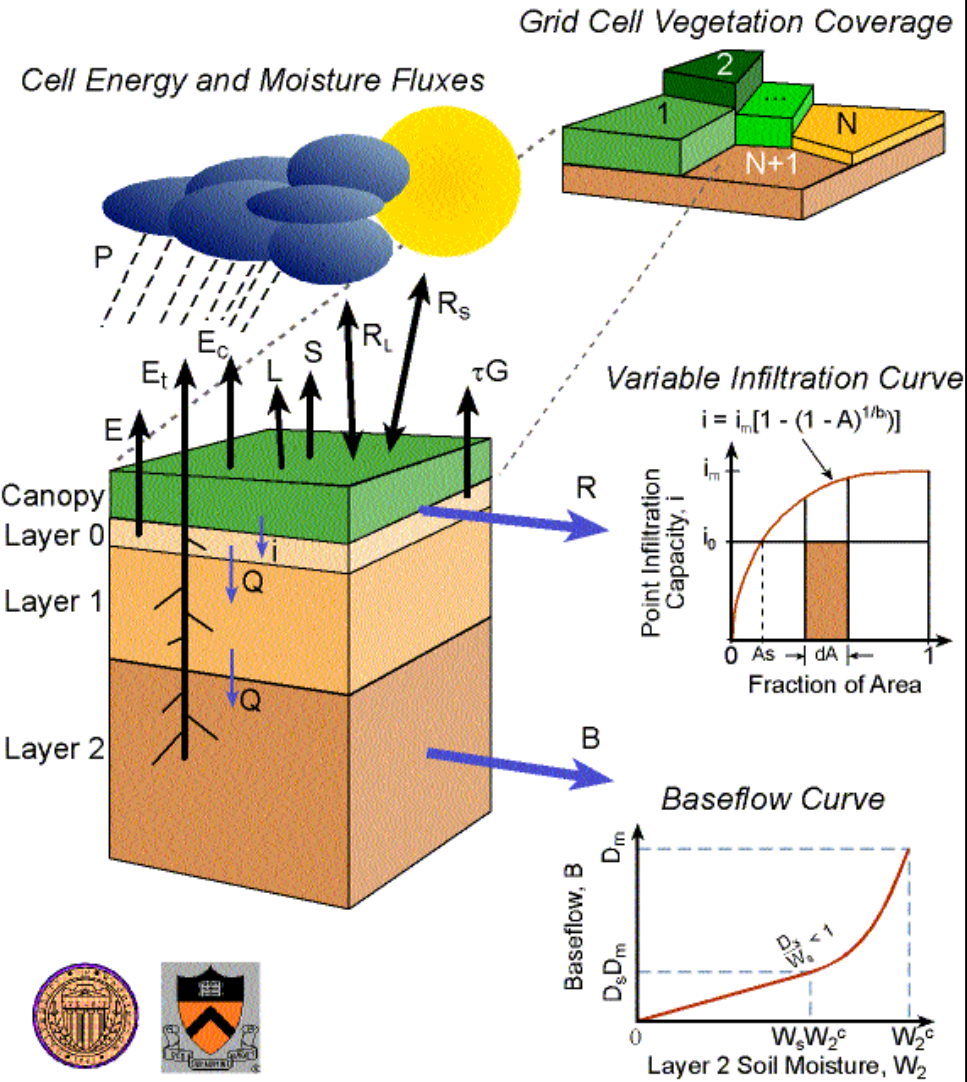
2) Accelerated Climate Prediction Initiative (ACPI)



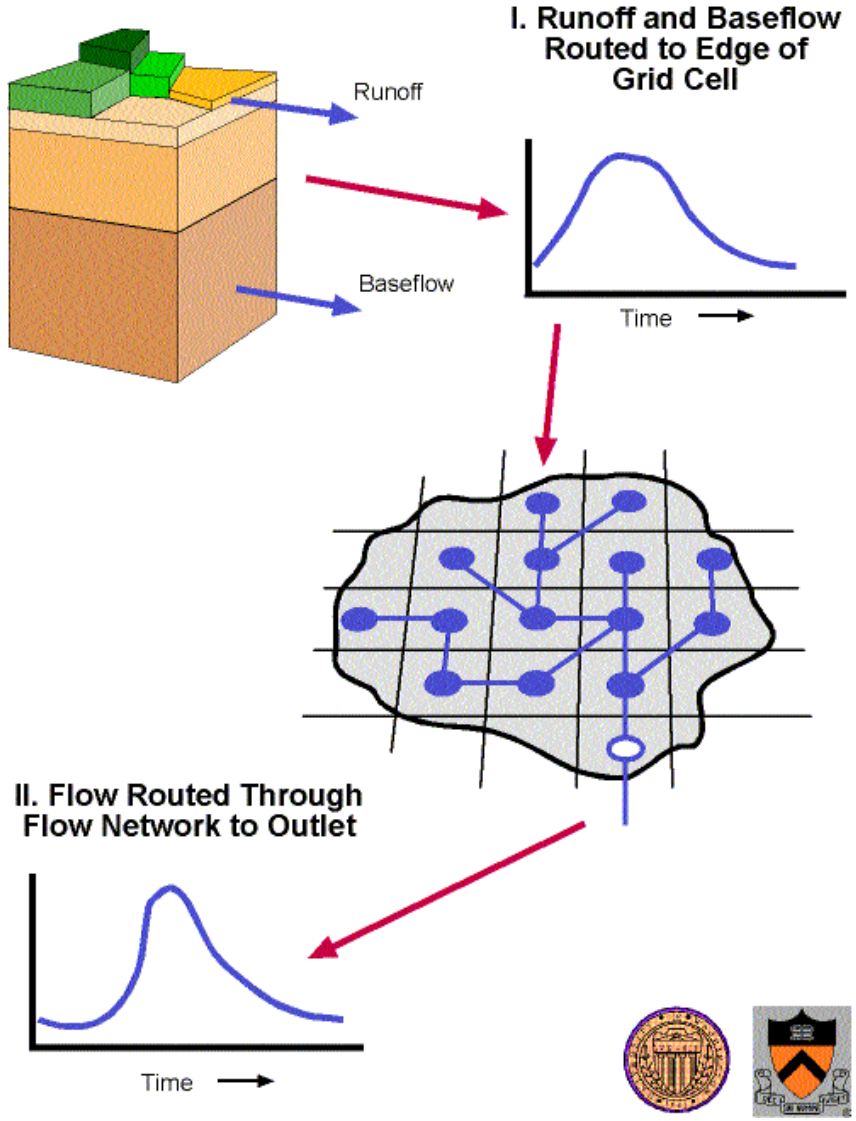
NCAR/DOE Parallel Climate Model (PCM) grid over western U.S.


Climate Scenarios
Global climate simulations, next ~100 yrs
Downscaling
Delta Precip, Temp
Performance Measures
Reliability of System Objectives
Hydrologic Model (VIC)
Natural Streamflow
Reservoir Model
DamReleases, Regulated Streamflow

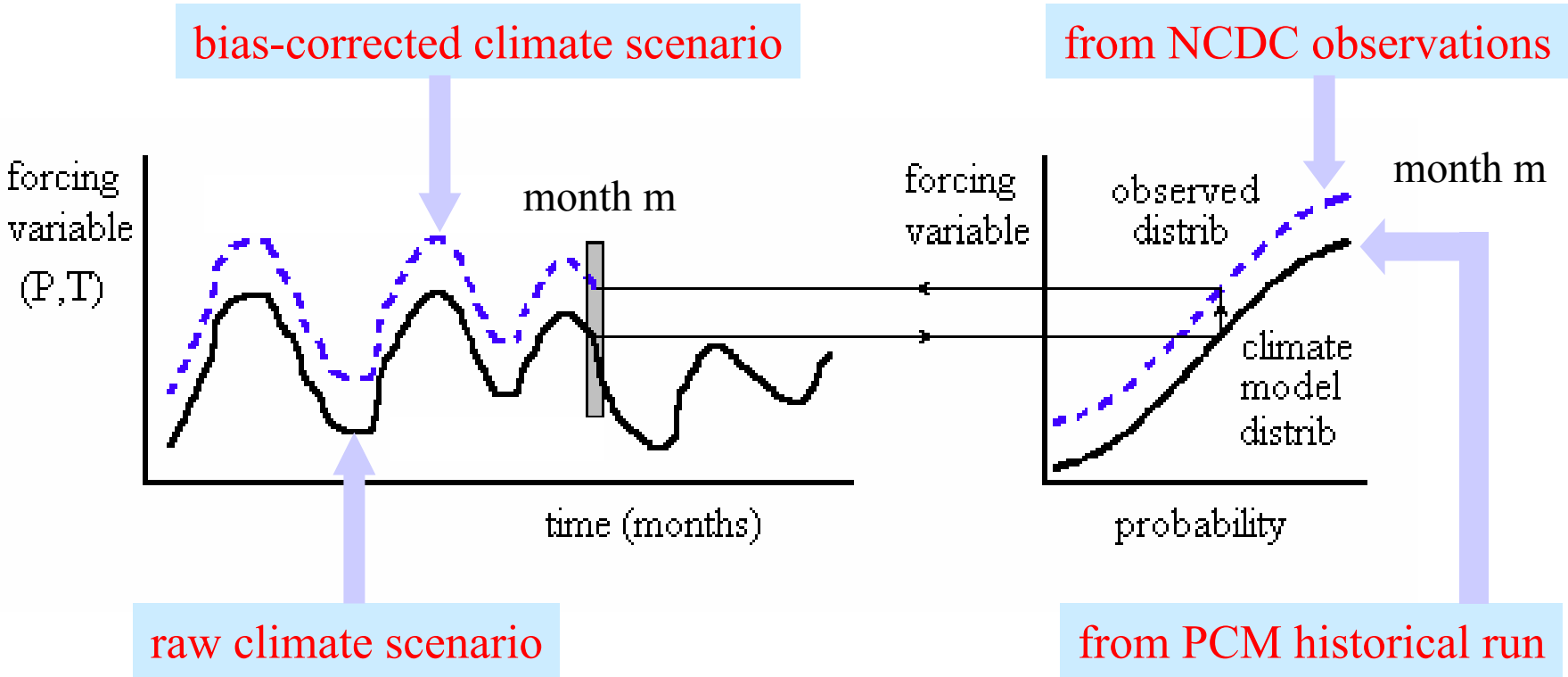
Variable Infiltration Capacity - n Layer (VIC-nL) Macroscale Hydrologic Model



River Network Routing Scheme for VIC-nL



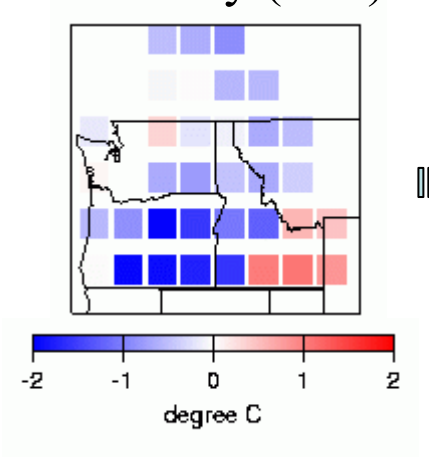
Bias Correction



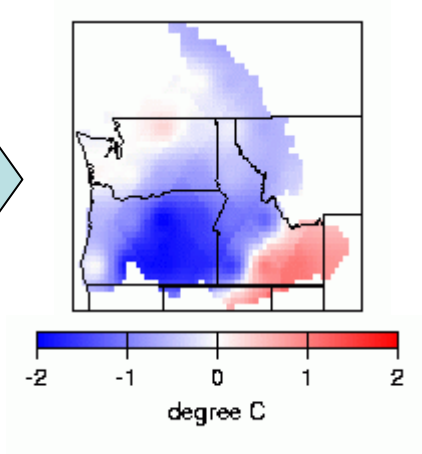
Note: future scenario temperature **trend** (relative to control run) removed before, and replaced after, bias-correction step.

Downscaling

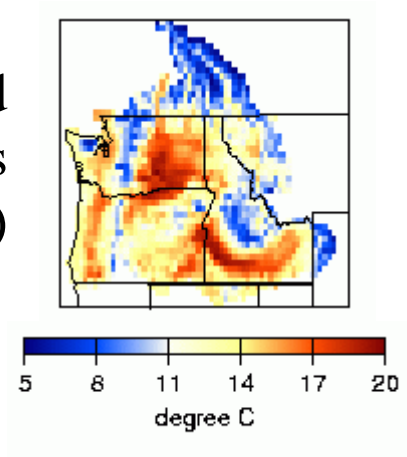
monthly PCM anomaly (T42)



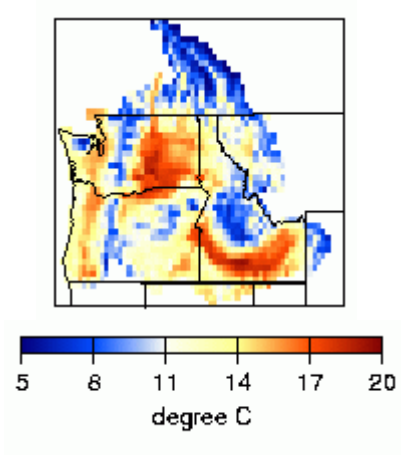
interpolated to VIC scale



observed mean fields (1/8-1/4 degree)



VIC-scale monthly simulation



BAU 3-run average

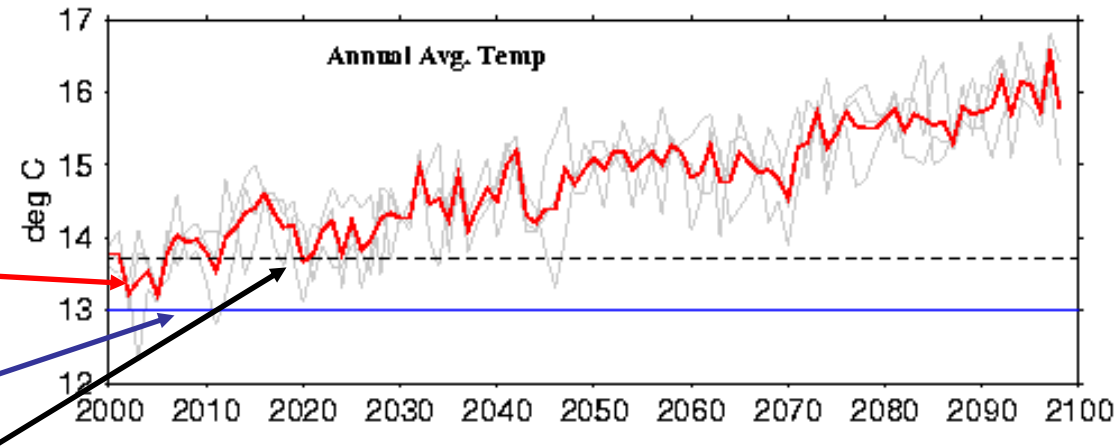
historical (1950-99)

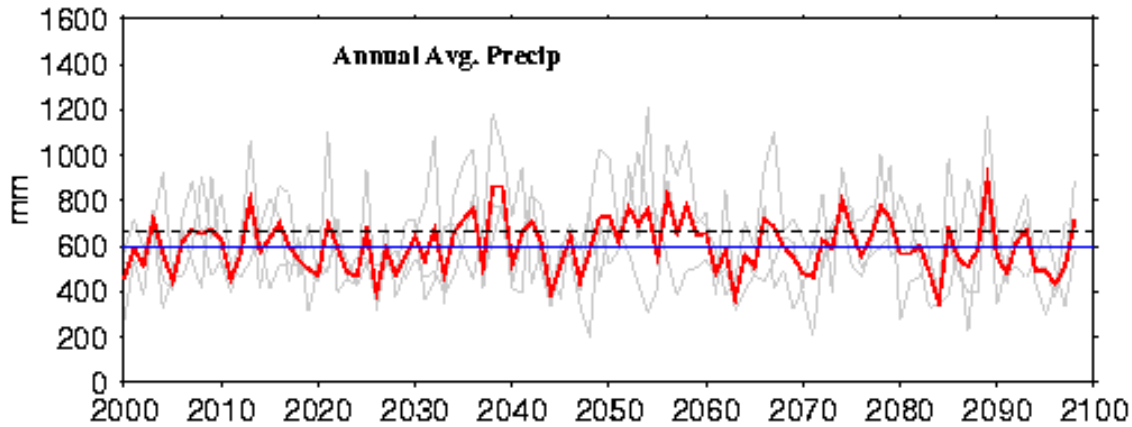
control (2000-2048)

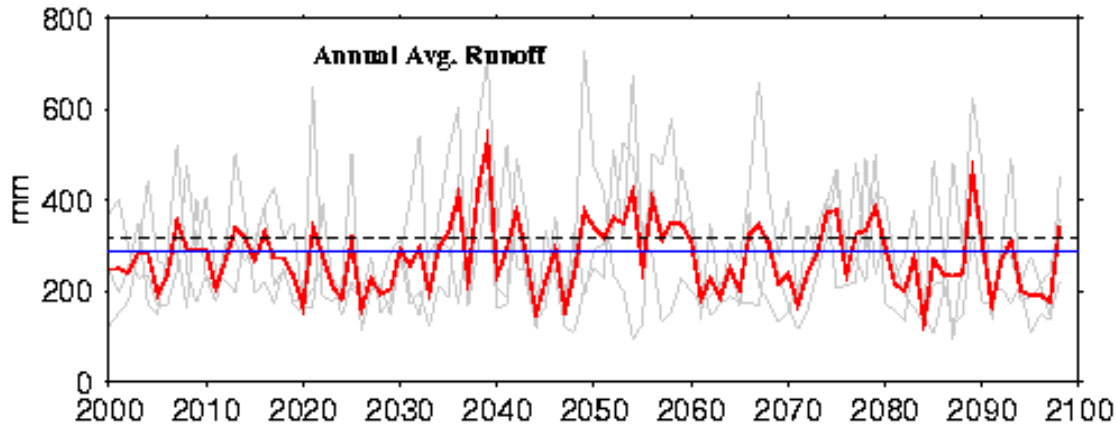
PCM

Business-as-Usual scenarios

California (Basin Average)







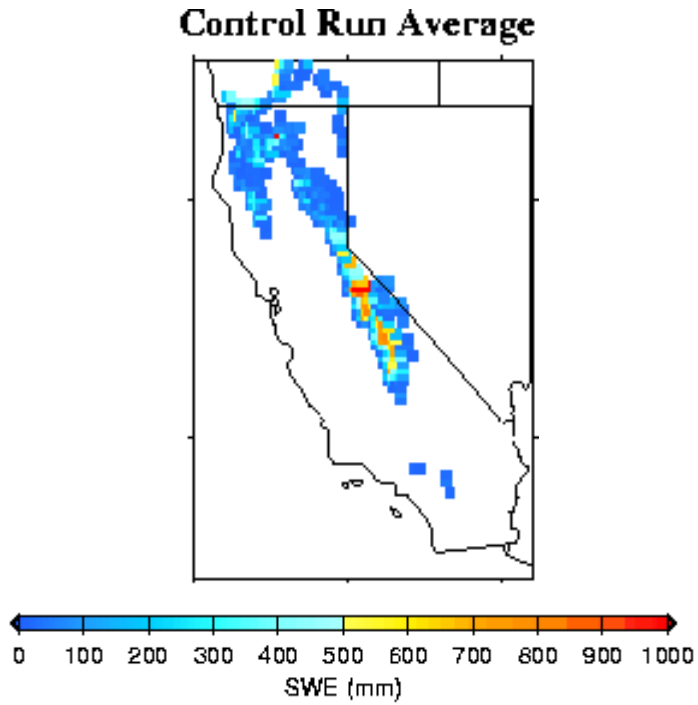
PCM

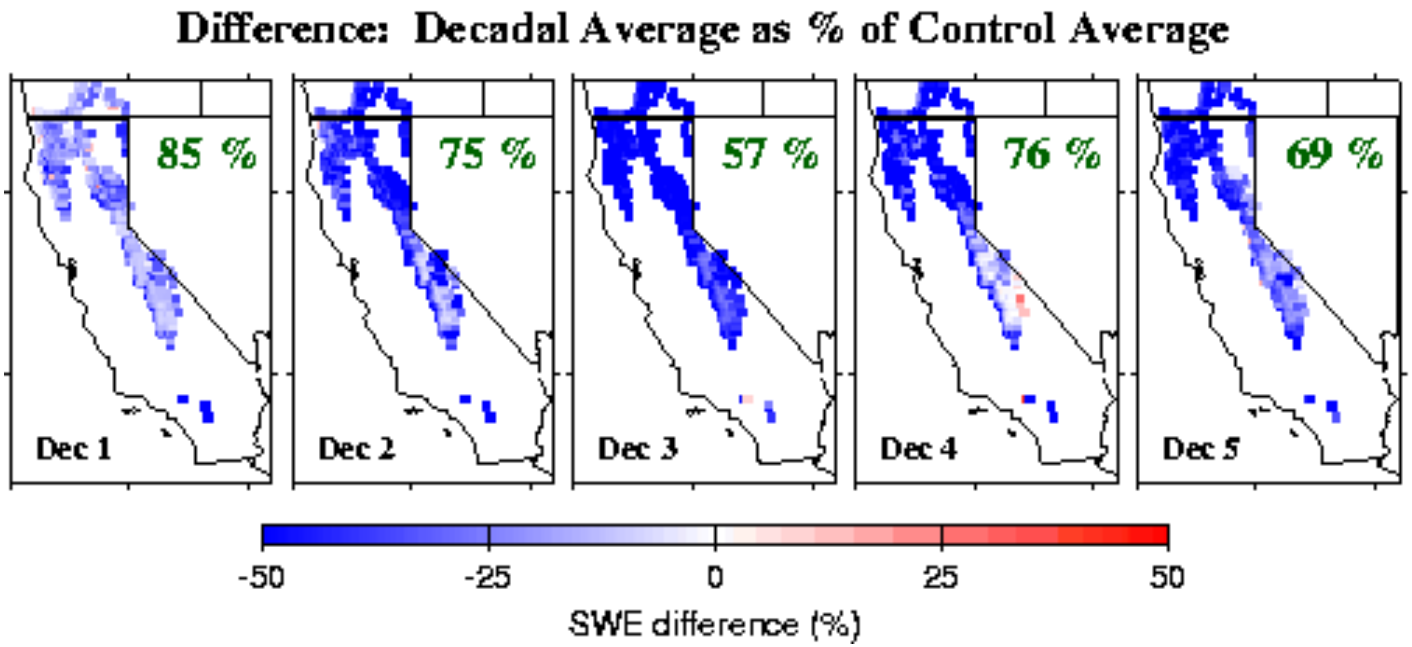
Business-as-Usual Scenarios

Snowpack Changes

California

April 1 SWE





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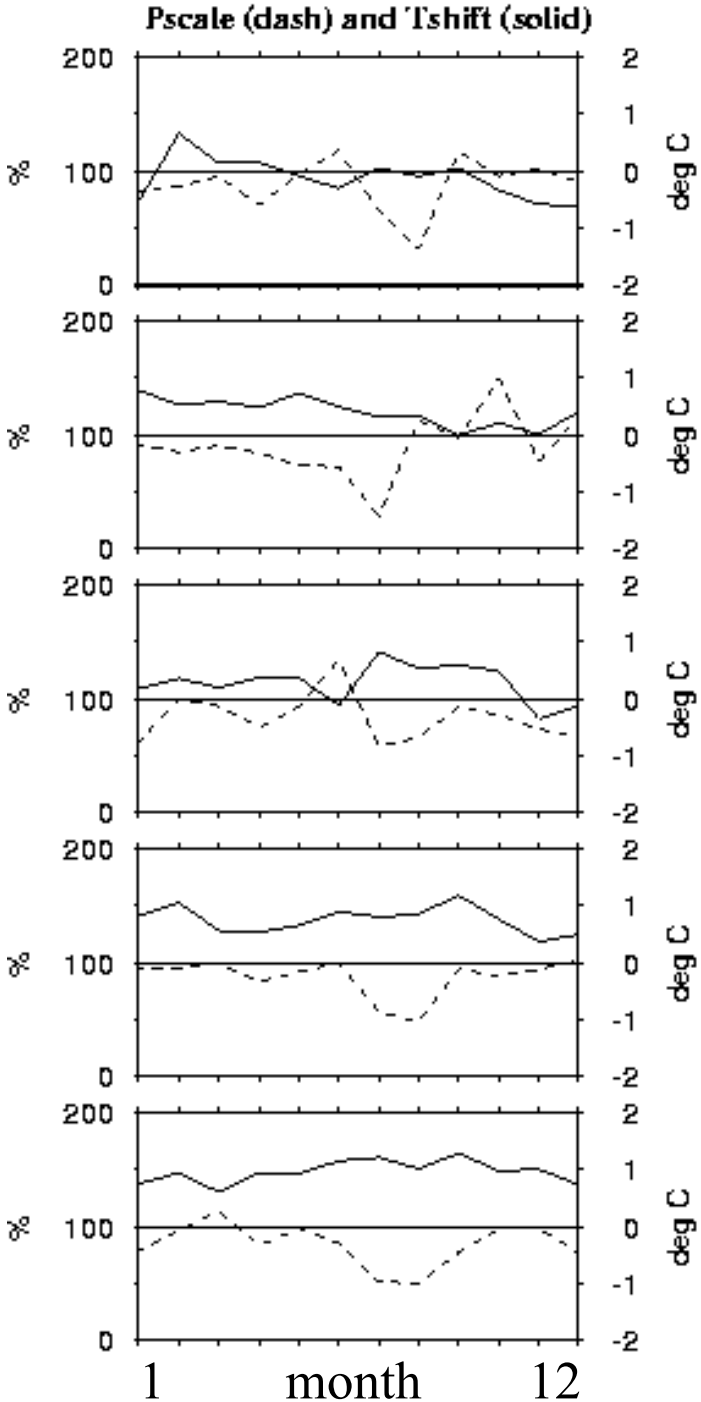
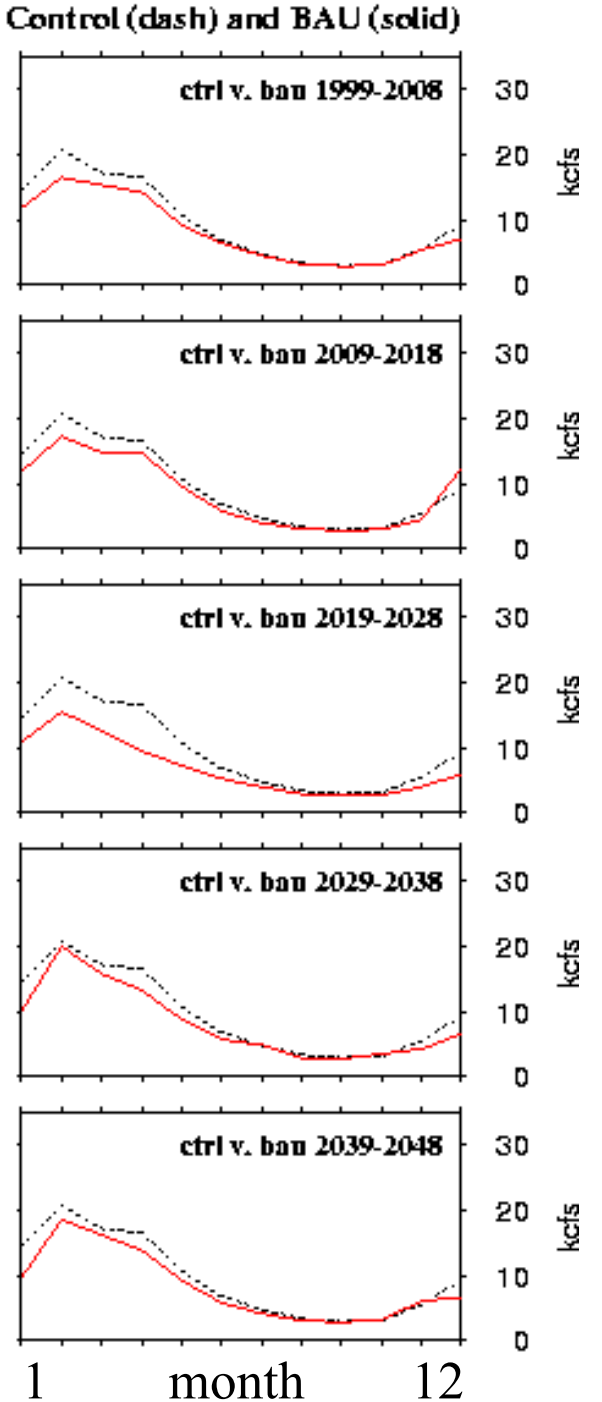
Business-As-Usual

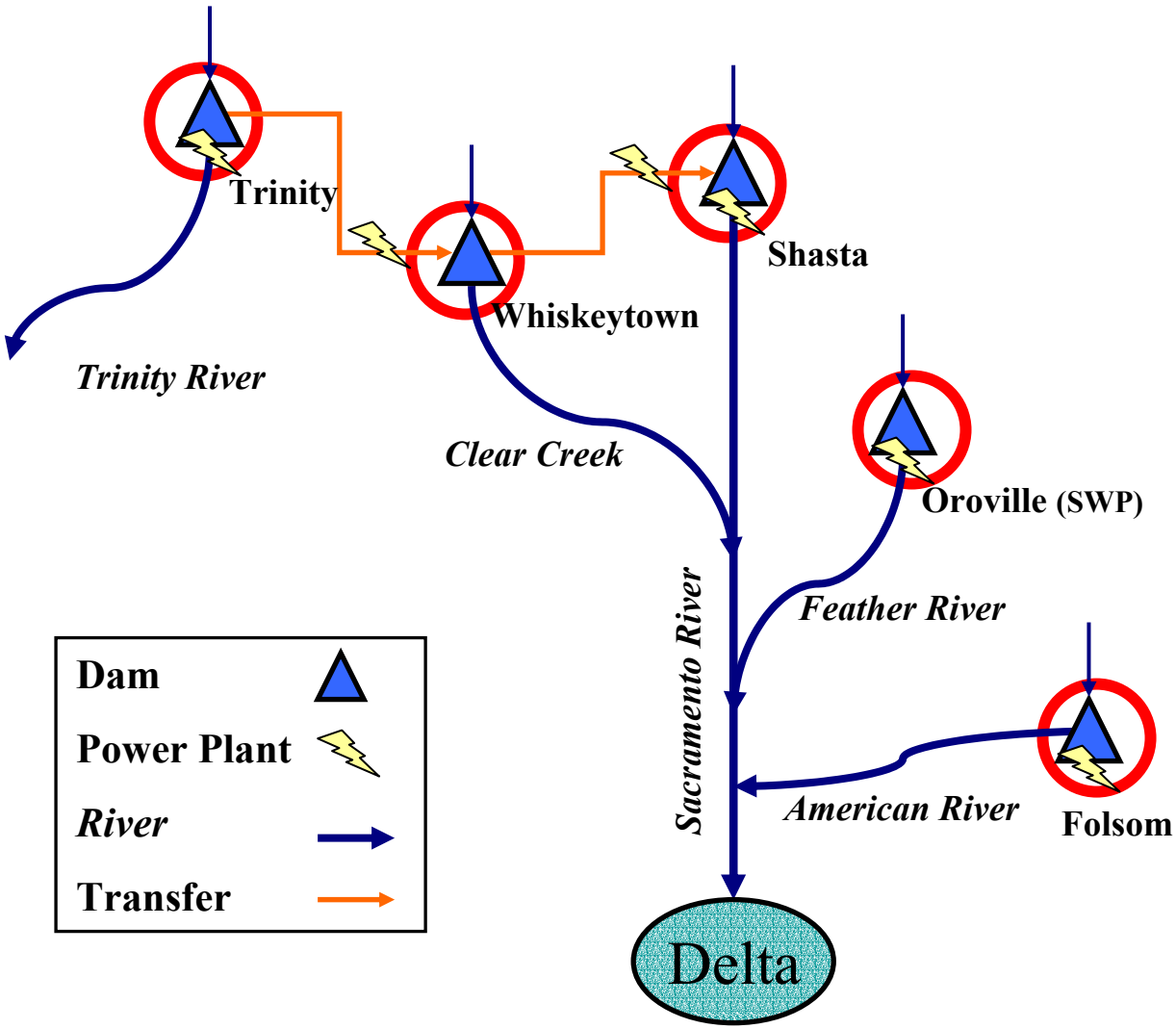
Mean Monthly Hydrographs

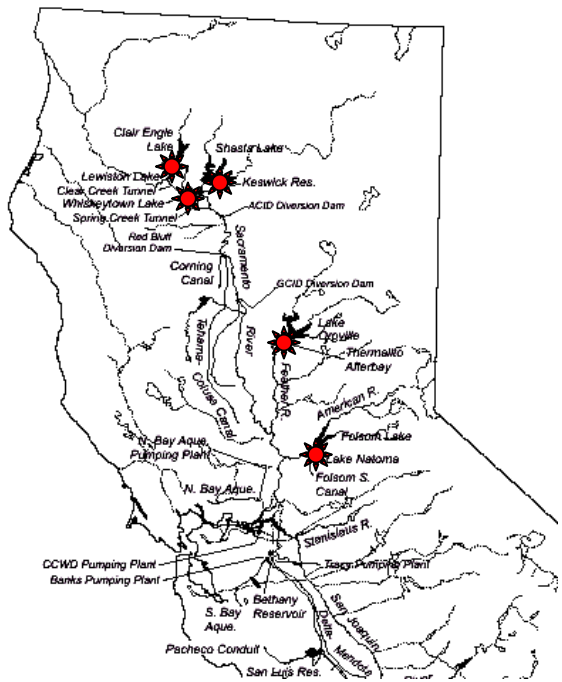
Shasta Reservoir Inflows





Sacramento River Basin





Delta & San Joaquin R Basin

Mokelumne River

Pardee & Camanche

Delta Outflow

Delta

Calaveras River

New Hogan

San Luis

San Joaquin River

Stanislaus River

New Melones

Tuolumne & Merced Rivers

Eastman, Hensley, & Millerton

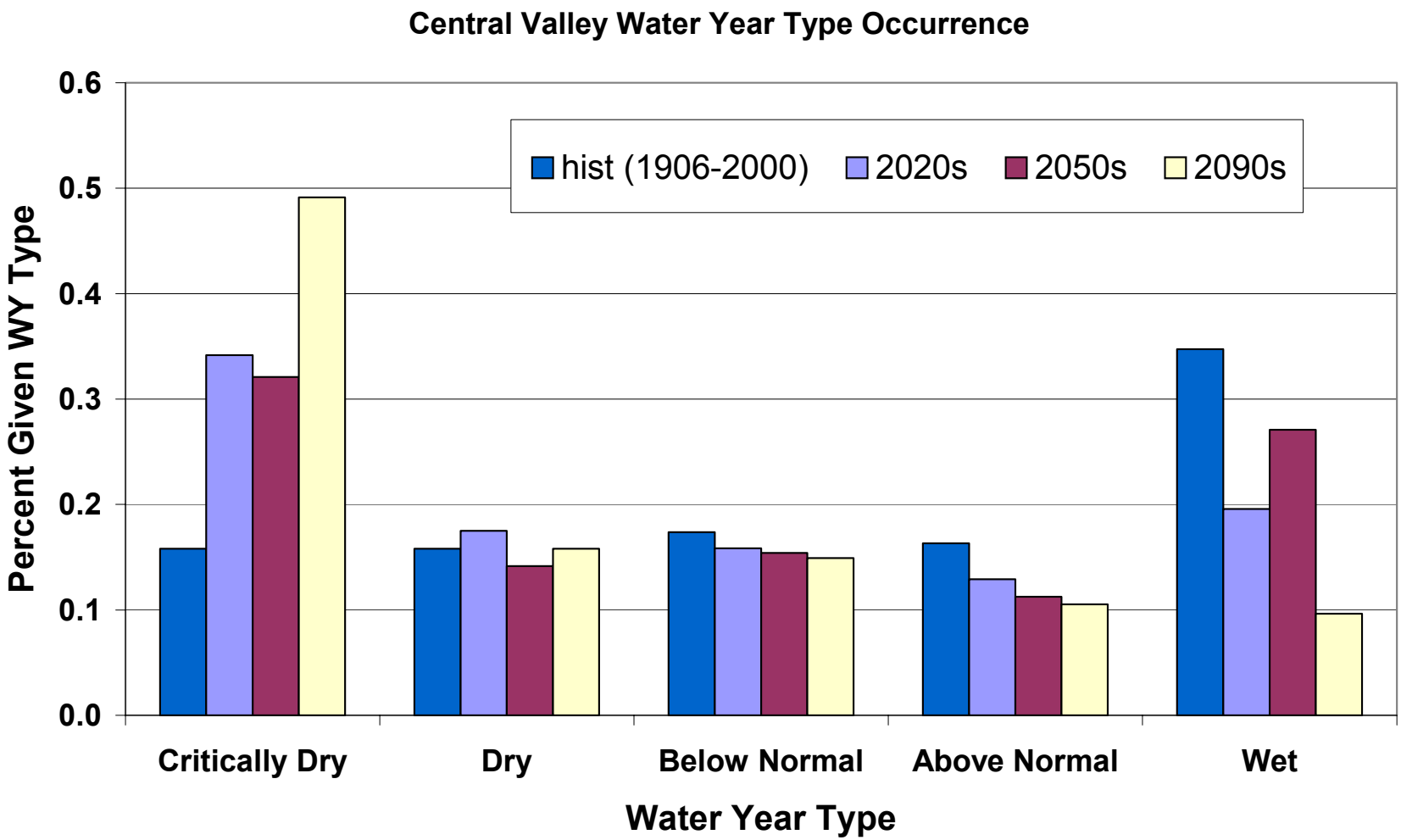
New Don Pedro & McClure

Dam

Power Plant

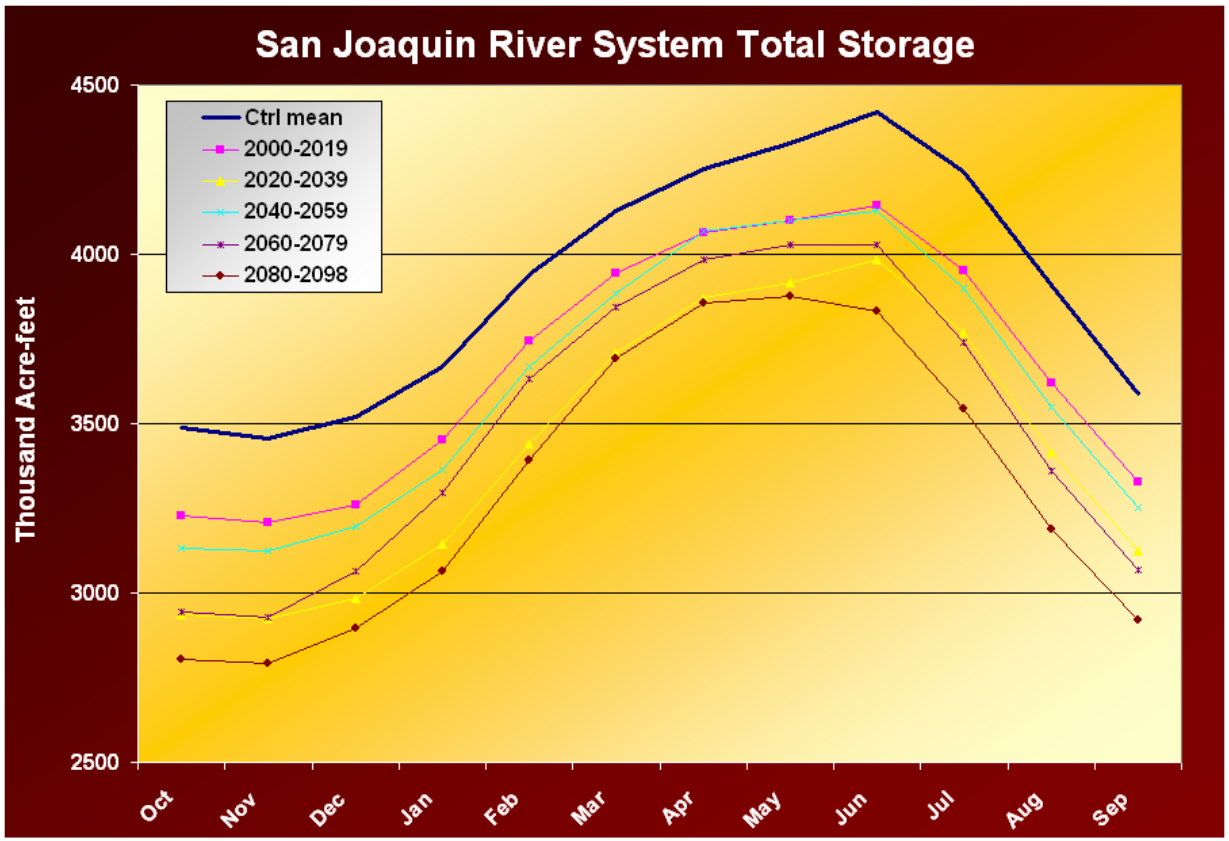
River/Canal

Transfer



from Van Rheenan et al, Climatic Change, 2004

Current Climate vs. Projected Climate

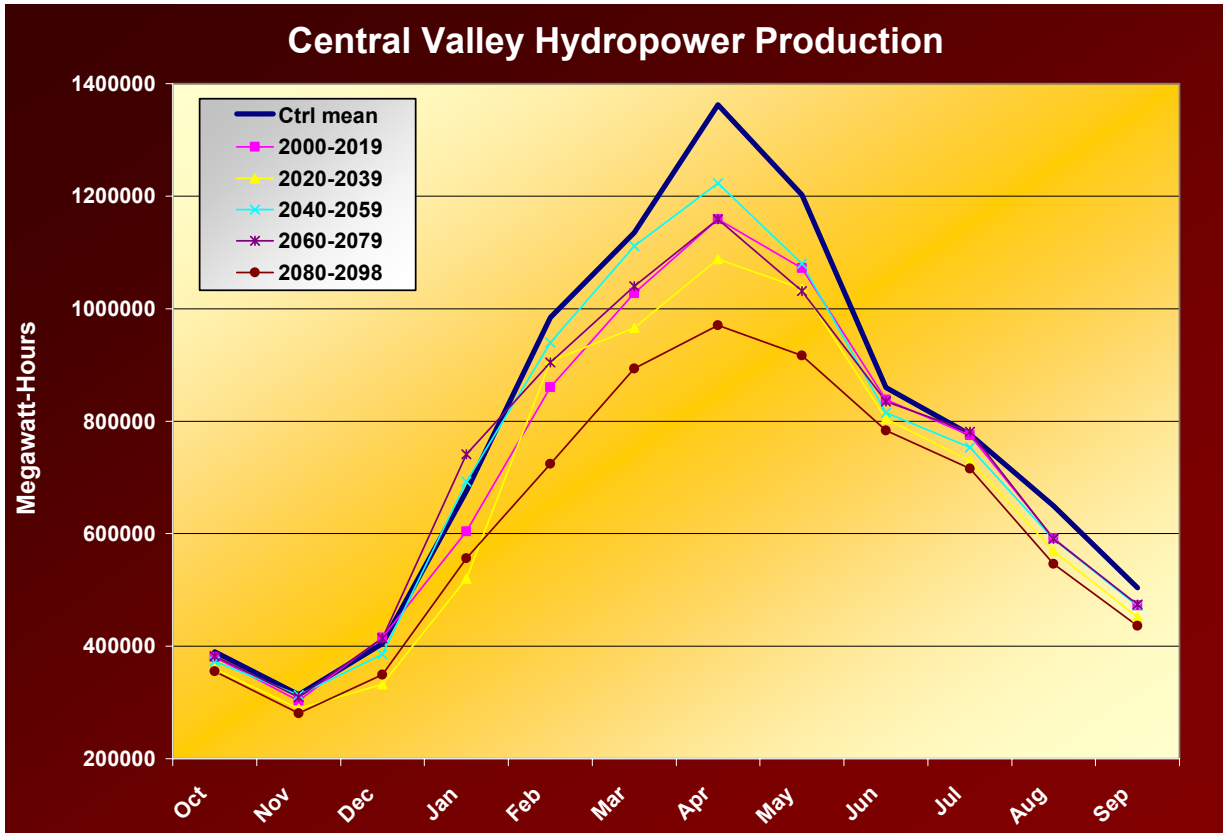


Storage Decreases

- Sacramento
  - Range: 5 - 10 %
  - Mean: 8 %
- San Joaquin
  - Range: 7 - 14 %
  - Mean: 11 %

from Van Rheenan et al, Climatic Change, 2004

Hydropower changes

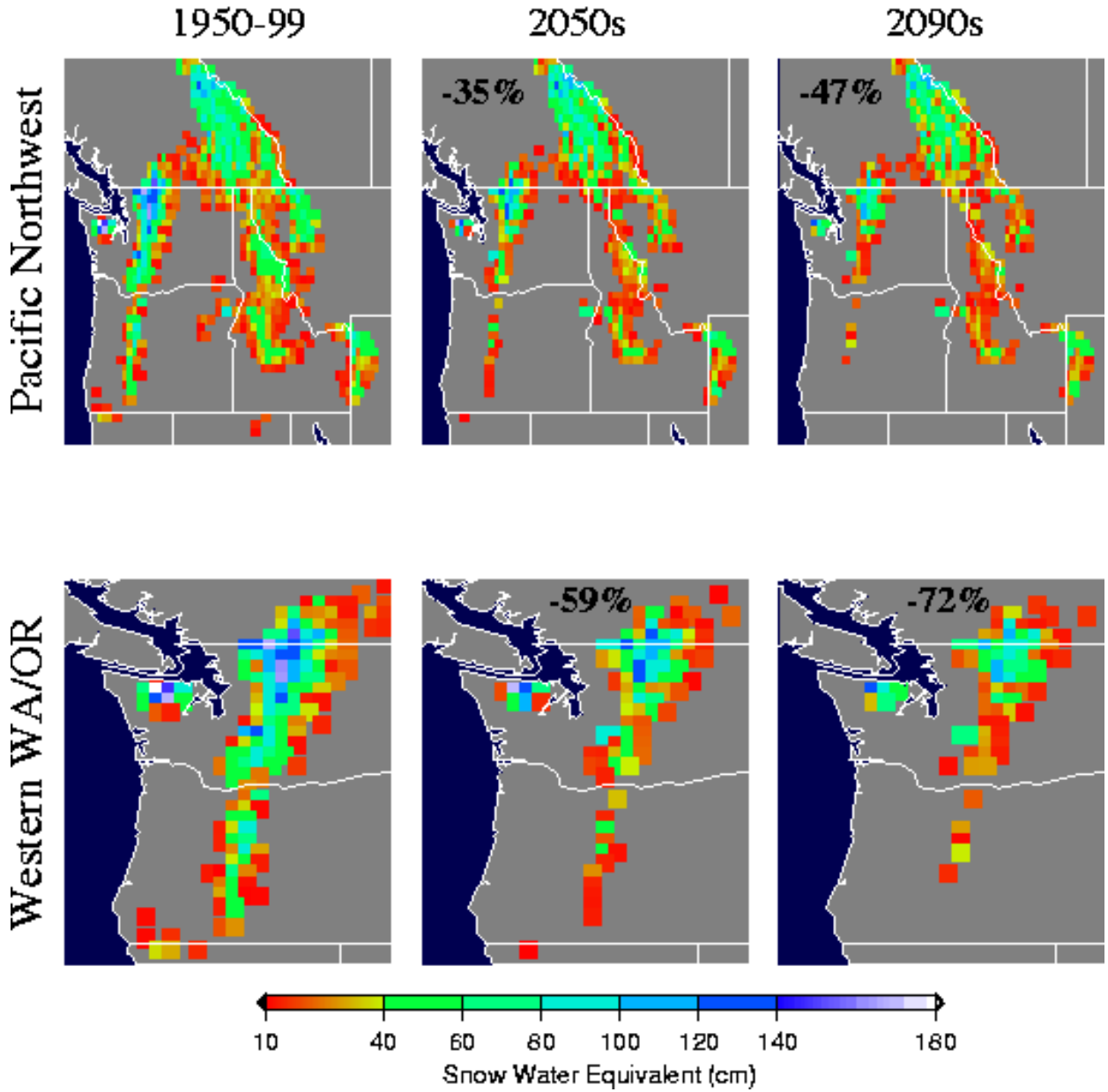


Hydropower Losses

- Central Valley
  - Range: 3 - 18 %
  - Mean: 9 %
- Sacramento System
  - Range: 3 – 19 %
  - Mean: 9%
- San Joaquin System
  - Range: 16 – 63 %
  - Mean: 28%

from Van Rheenan et al, Climatic Change, 2004

April 1 snowpack projections – Columbia River basin

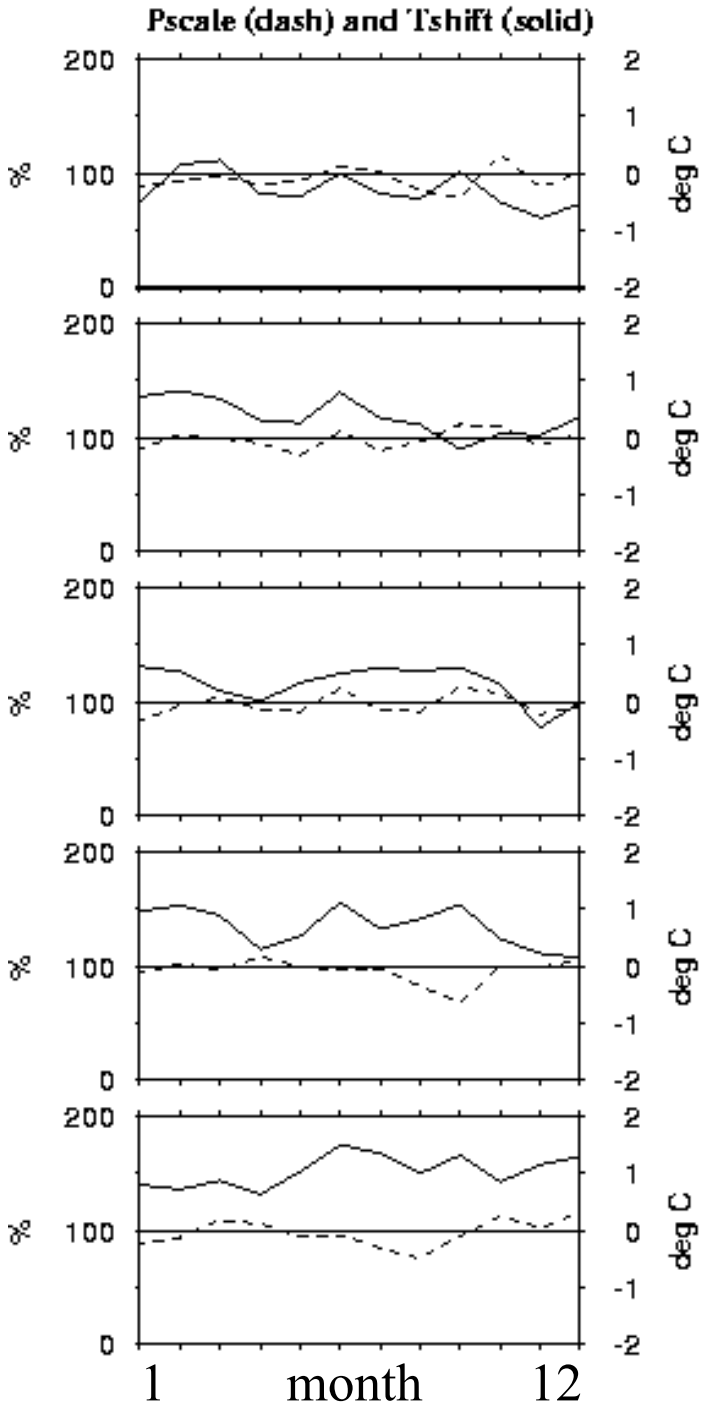


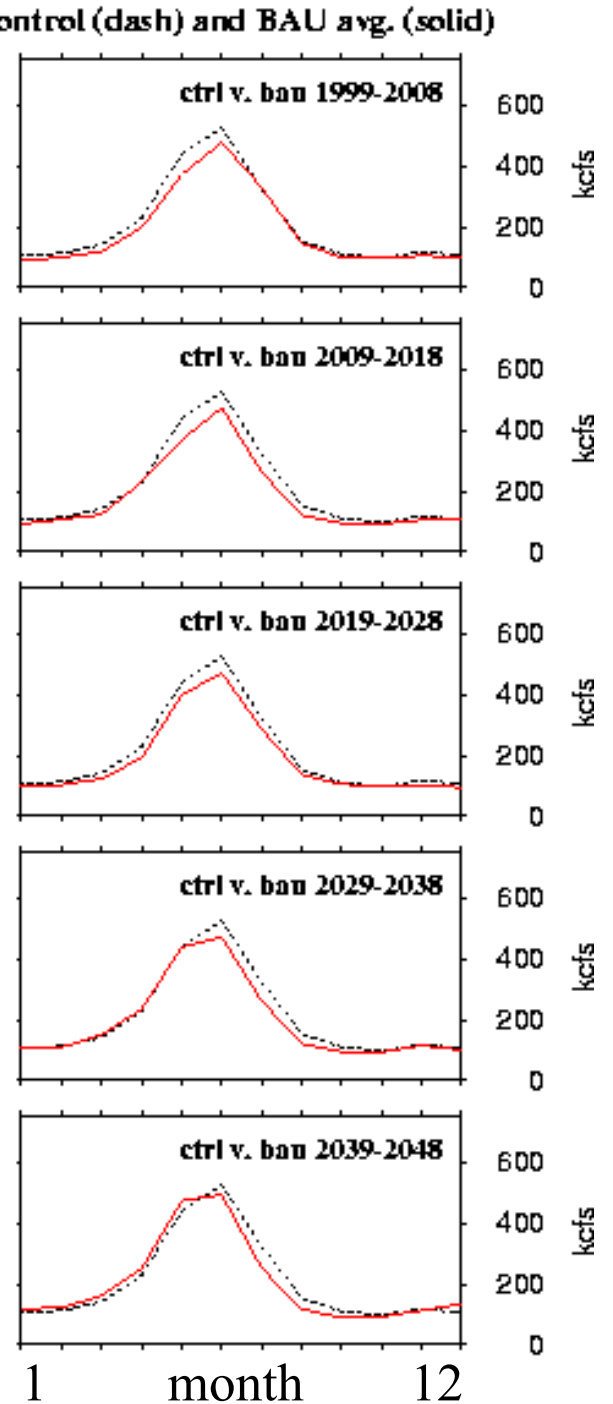
PCM

Business-As-Usual

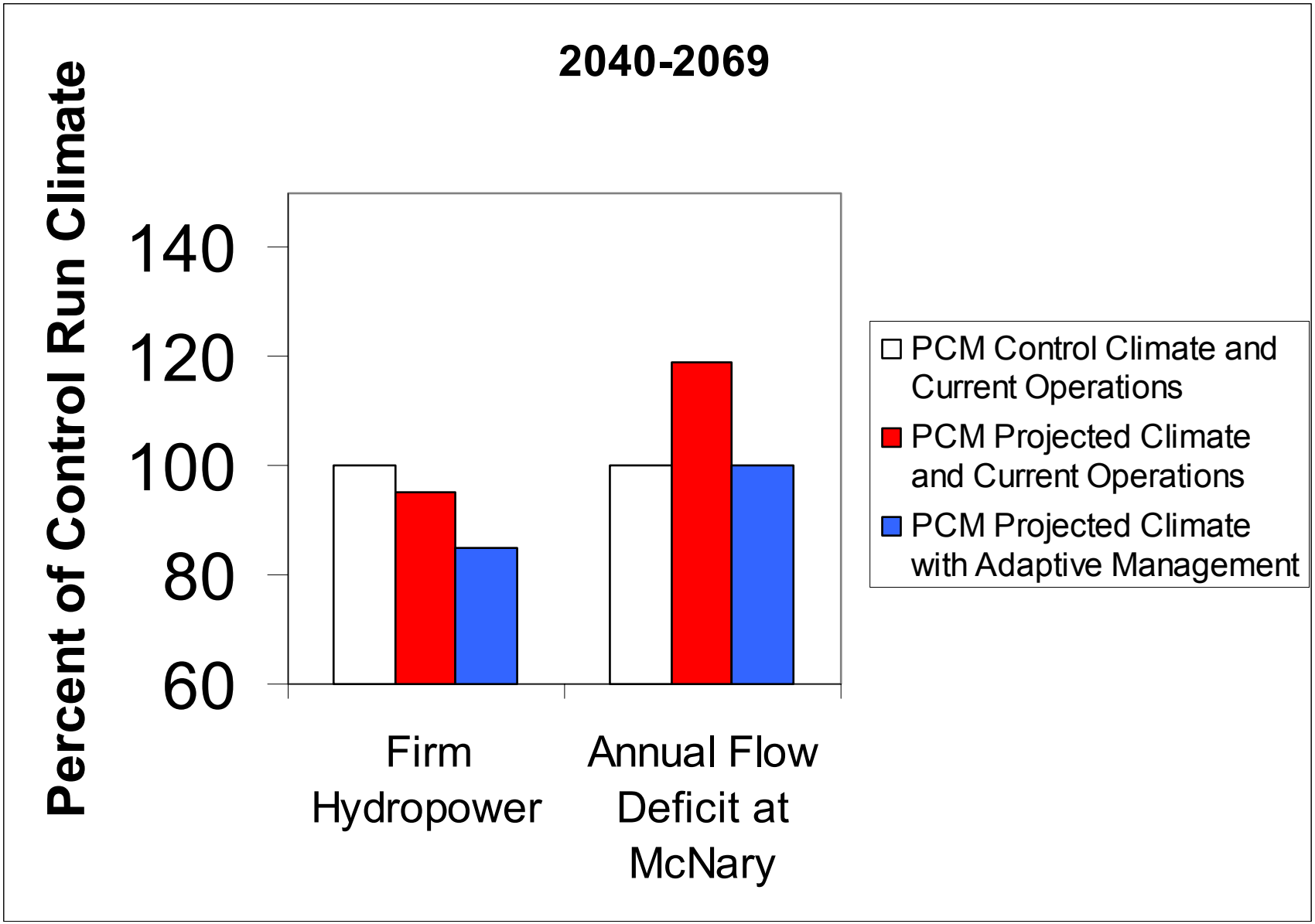
Mean Monthly Hydrographs

Columbia River Basin @ The Dalles, OR

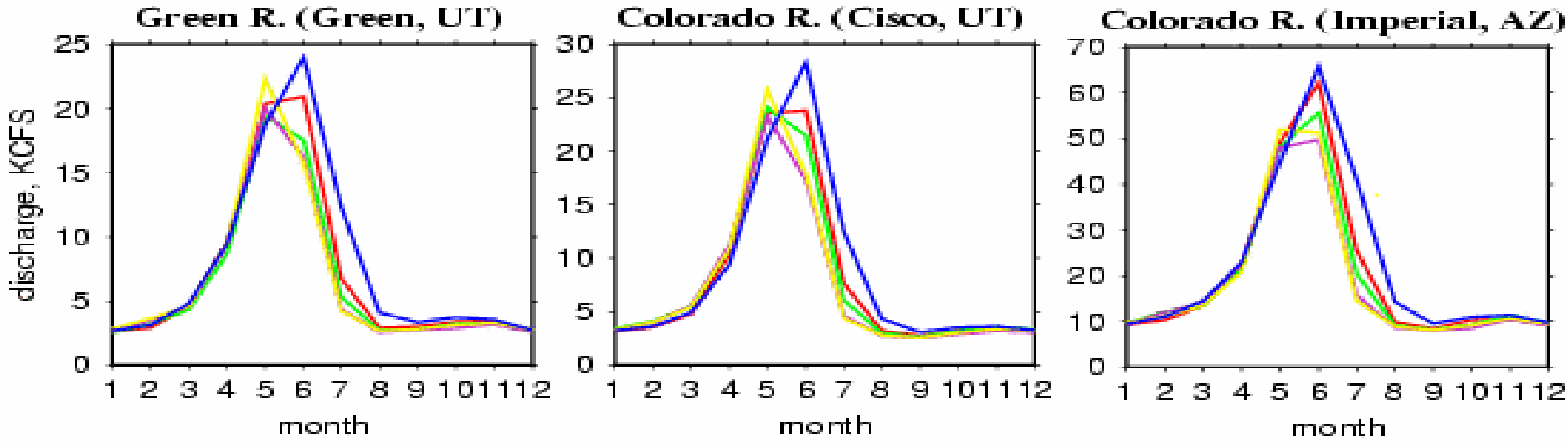




Projected hydropower changes – Columbia River basin



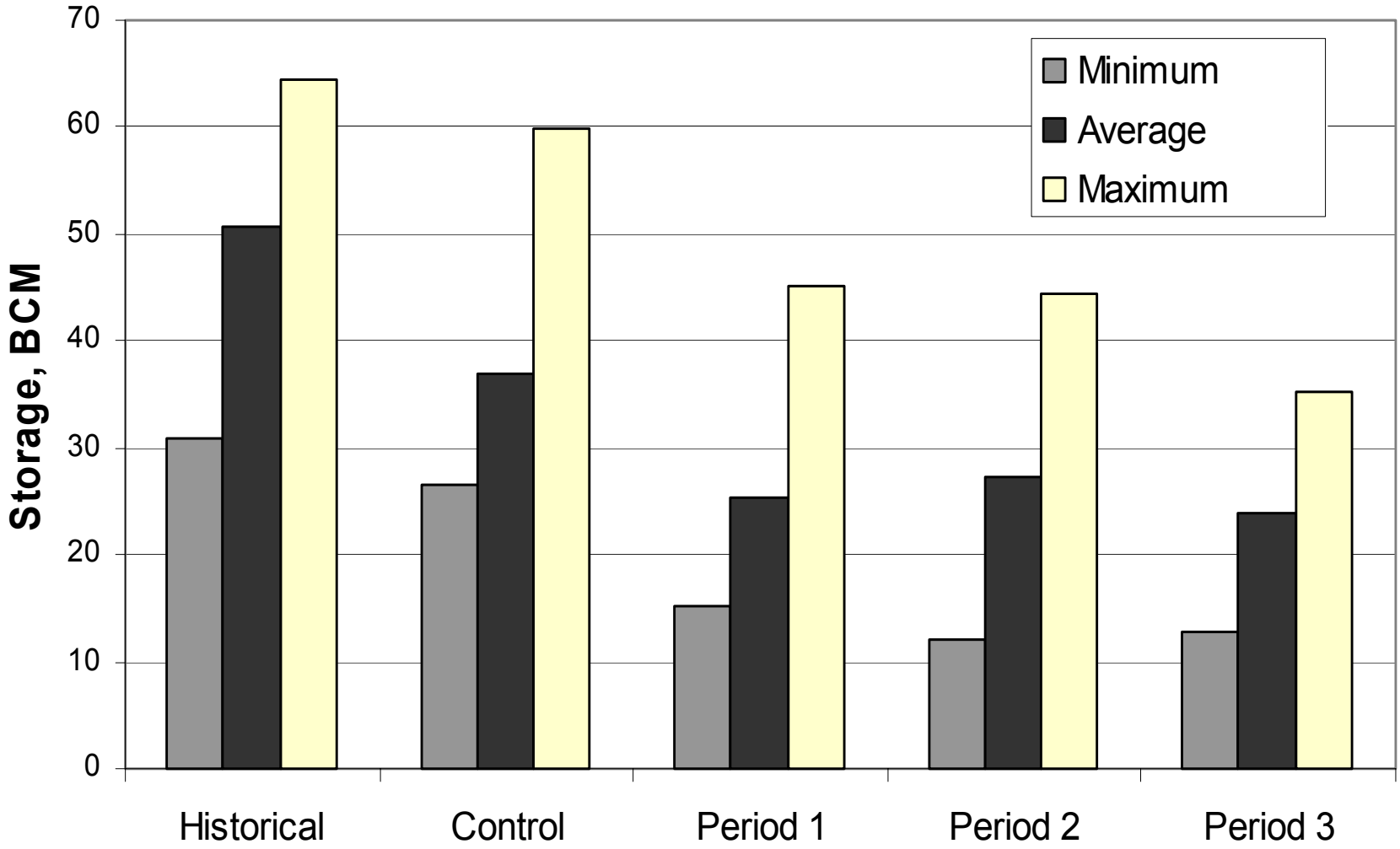
Annual Average Hydrographs – Colorado River and tributaries



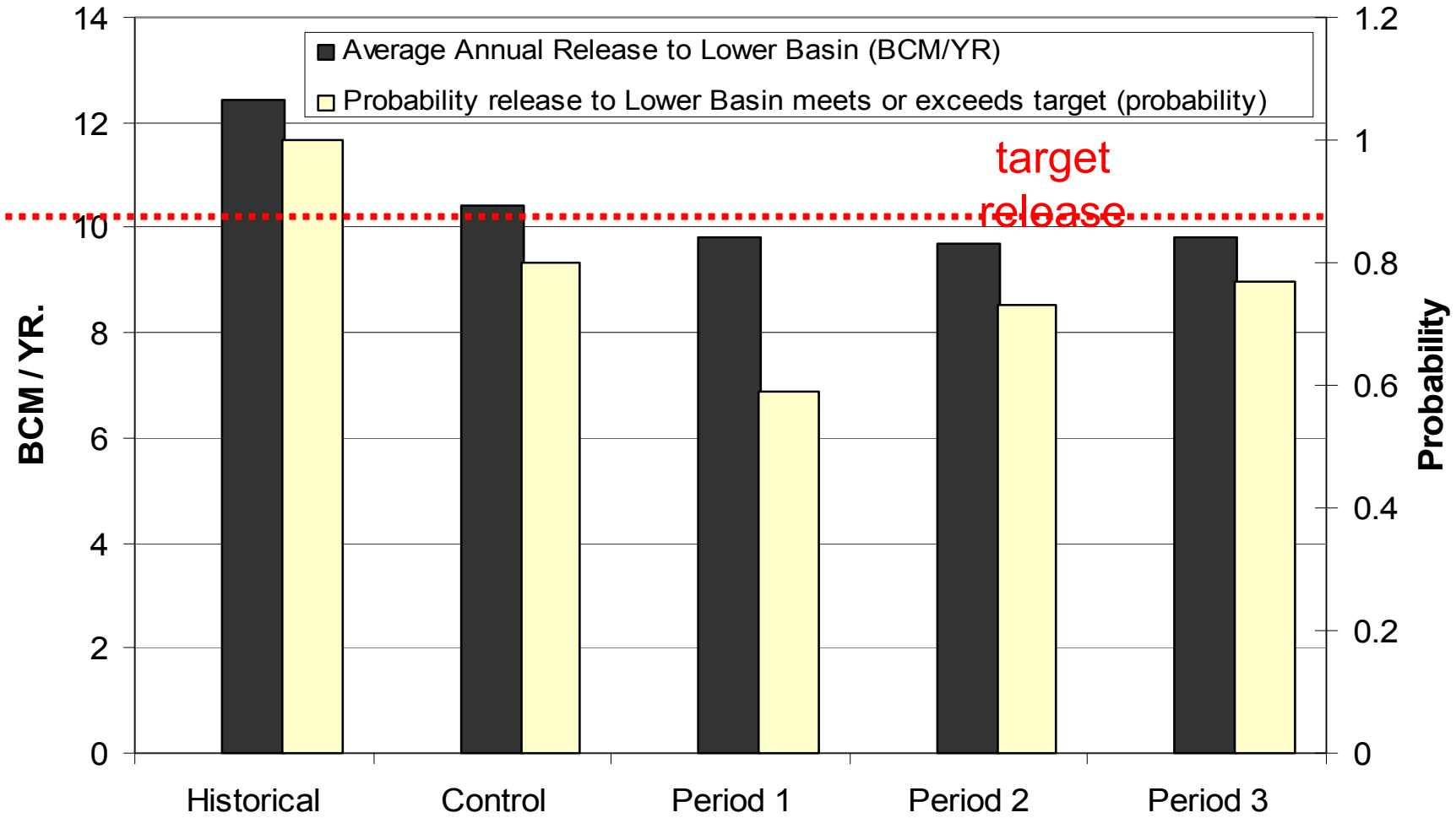
Simulated Historic (1950-1999)
Control (static 1995 climate)

Period 1 (2010-2039)
Period 2 (2040-2069)
Period 3 (2070-2098)

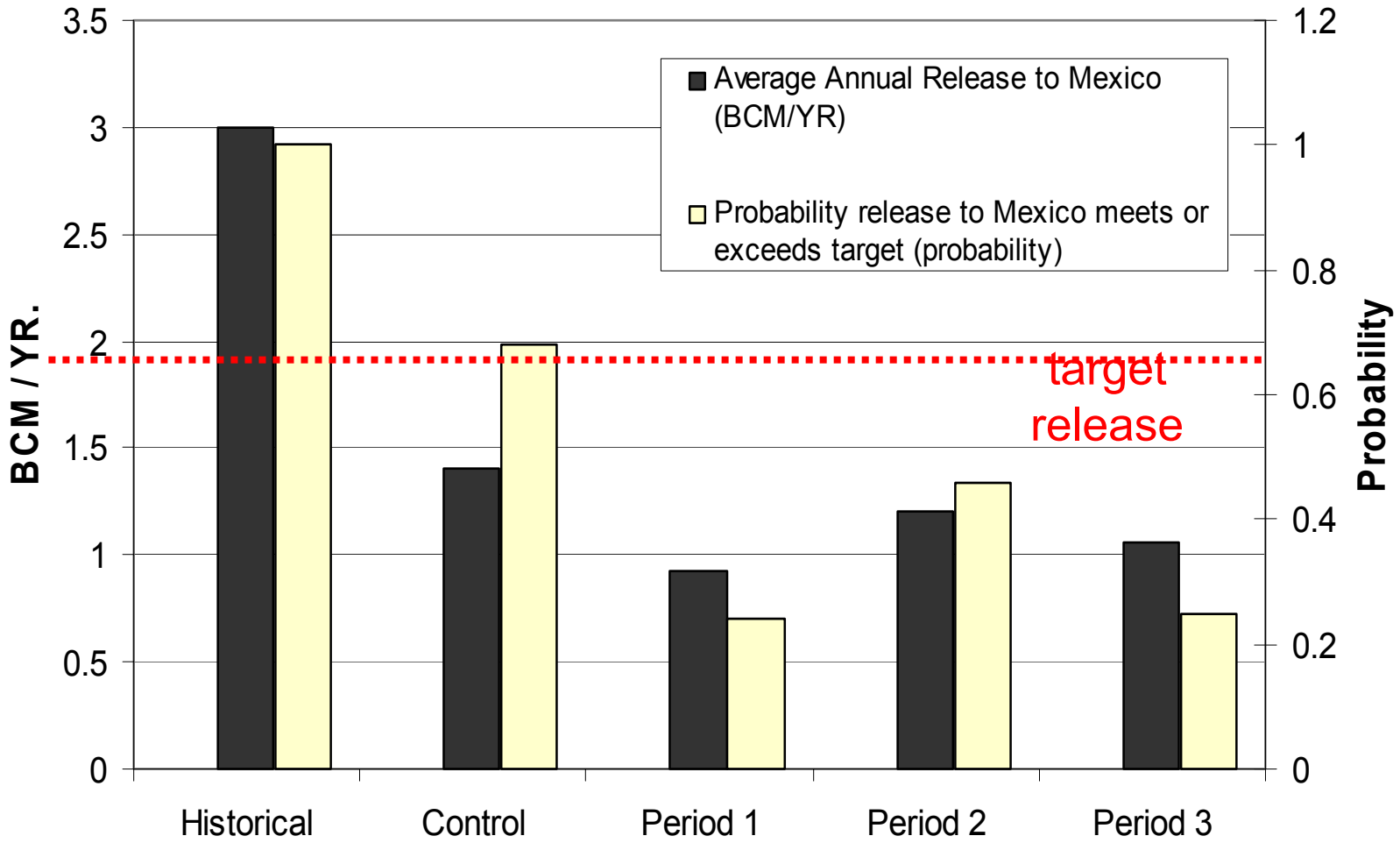
Total Basin Storage



Annual Releases to the Lower Basin



Annual Releases to Mexico



Conclusions

- **In 15+ years since Gleick and EPA studies, models have improved, but main conclusion is the same: seasonal shifts in hydrographs (especially in the transient snow zone) will be the cause of significant disruptions to California (and western U.S.) water management**
- **California system operation is dominated by water supply (mostly ag), reliability of which would be reduced significantly by a combination of seasonality shifts and reduced (annual) volumes. Partial mitigation by altered operations is possible, but complicated by flood issues.**
- **Climate sensitivities in Columbia basin are dominated by seasonality shifts in streamflow, and may even be beneficial for hydropower. However, fish flow targets would be difficult to meet under altered climate, and mitigation by altered operation is essentially impossible.**
- **Colorado system is sensitive primarily to annual streamflow volumes. Low runoff ratio makes the system highly sensitive to modest changes in precipitation (in winter, esp, in headwaters). Sensitivity to altered operations is modest, and mitigation possibilities by increased storage are nil (even if otherwise feasible).**